Loanword Phonology in New Zealand English: Exemplar Activation and Message Predictability

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ABSTRACT

This thesis explores the production of loanwords. When a word is borrowed from one language to another language, the word may contain a sound or structure that is not permitted in the grammar of the borrowing language. The non-native structure may be adapted to make it well-formed in the borrowing language, or it may be imported without modification. For example, a word borrowed from te reo Māori to New Zealand English (NZE) may contain a non-native rhotic sound [ɾ], and the non-native sound is sometimes adapted as a native rhotic sound (e.g. *ko*[ɹ]*u* and *ma*[ɹ]*ae*), and sometimes imported (e.g. *ko*[ɾ]*u* and *ma*[ɾ]*ae*). By exploring the variation in /r/ realizations in Māori loanwords, this thesis addresses research questions regarding (a) the likelihood of choosing a variant and (b) the degree of phonetic redundancy in the pronunciation.

The first part of this thesis (Chapters 3-5) explores the effect of sociolinguistic factors on the likelihood of choosing adapted structure [ɹ] vs. imported structure [ɾ], by running three experiments. It is demonstrated that the choice is affected by some sociolinguistic factors, i.e., imported structure is more likely to be produced in speech associated with Māori, by speakers associated with Māori, and in loanwords associated with Māori. Addressing these questions increases our understanding of the relationship between loanword phonology and sociolinguistic factors, which has been less studied in previous literature. These findings suggest that the variation in loanword phonology can be socially meaningful, because variation in loanword phonology is a type of inter-speaker and intra-speaker variation (Bell 2014). Namely, adapted structure and imported structure carry different social messages. In particular, it is argued that imported structure has a social message associated with Māori.

On the basis of the argument for the social messages, the second part of this thesis (Chapters 6-7) explores the relationship between the phonetic redundancy in a variant in loanword phonology (i.e., adapted structure and imported structure) and the social message predictability, by analysing the data collected from the three experiments again. It is shown that imported structure [ɾ] is produced with *less* acoustic redundancy (i.e., shorter formant cessation) when it is more predictable from context; adapted structure [ɹ] is produced with *more* acoustic redundancy (i.e., a lower F3 value) when it is more predictable from context. This increases our understanding of the relationship between the realization of a linguistic unit and predictability in general. More specifically, this indicates that the phonetic redundancy in a signal is not only influenced by lexical message predictability as has been demonstrated in previous literature, but it is also affected by social message predictability.

At a theoretical level, investigating the two research questions provides insights to the cognitive process of loanword phonology. More specifically, the research on the likelihood of choosing a variant in loanword phonology develops our understanding of how adapted structure and imported structure are represented in the mind of a borrower. The result could be captured by positing that exemplars with adapted structure and imported structure are represented, the

exemplar space is developed through the usage of loanwords, and the representation of imported structure is stored in relation to a social category "Māori" (Pierrehumbert 2001; Foulkes and Docherty 2006). The research on redundancy in a variant increases our understanding of how adapted structure and imported structure are processed in production. The result could be encapsulated by positing that the phonetic realization of imported structure [ɾ] is highly influenced by articulatory biases which balance accuracy of message transmission and resource cost (Hall et al. 2016; 2018), and the realization of adapted structure [ɹ] is highly influenced by averaging exemplars with adapted structure and those with imported structure. The reason why the two structures are influenced by different mechanisms is due to the saliency of the social messages. It is speculated that the realization of a linguistic variant is more likely to be affected by message-oriented production biases, when the social message is salient; otherwise, it is more likely to be affected by exemplar-averaging processes.

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Chapter 1 Introduction

1.1 Aim of this thesis

The aim of this thesis is to study the pronunciation of loanwords. Loanwords are words that are borrowed from one language into another language. For example, *hoki* [hóʊkɪ], *pukeko* [puːkékoʊ], and *Wanaka* [wʊ́nəkə] are loanwords borrowed from te reo Māori into New Zealand English (Deverson & Kennedy 2005). As discussed in Section 1.2, it is known that there is variation in the pronunciation of loanwords, because loanwords can be pronounced with native sounds or non-native sounds.

The choice of a linguistic variant may depend on sociolinguistic factors. For example, male speakers tend to choose an apical variant [ɪn] of an ING-morpheme in English, whereas female speakers tend to select a velar variant [ɪŋ]. This variation is affected by sociolinguistic factors such as gender. When a pattern of variation is sociolinguistically motivated, that variation is considered sociolinguistically meaningful (Eckert 2016), and a variant is considered to carry a social message such as masculinity or femininity. As reviewed in 1.3, less is known about the effect of sociolinguistic factors on choosing a pronunciation variant of a loanword. One of the aims of this thesis is to provide insights into *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors* **[RQ1a]**. It will be demonstrated in Chapters 3-5 that the choice is affected by some sociolinguistic factors (e.g., topic in speech, and speakers' and words' association with a source language and its culture). These findings suggest that variation in loanword phonology is socially meaningful, that is, a pronunciation variant of a loanword carries a particular social message.

Language is a system of message transmission, which conveys a variety of messages such as social messages and lexical messages. As noted above, social messages convey information regarding speakers' social identity including geographical and social origins, and the social relationship with both the listener and the community. A speaker could express a social message by choosing one linguistic variant as opposed to another variant. In the case of the above example of ING-morphemes, a speaker may express "formality" and "intelligence" by producing a velar variant as opposed to an apical variant (Campbell-Kibler 2007; Eckert 2008). Lexical messages are carried by words, and so a speaker expresses a lexical message by producing a word carrying that message. For example, a speaker can refer to a particular animal by producing the word *penguin*.

It has been demonstrated that when a lexical message is predictable given a context, the linguistic unit carrying the message, that is, the word is produced with a reduced signal. As reviewed in 1.4, a word is produced with shorter duration when it is more predictable given a context such as a preceding word and a following word (Jurafsky et al. 2001; Bell et al. 2003). The motivation for this probabilistic reduction is hypothesized to be that the lexical message carried by a predictable word is not important for the accuracy of message transmission,

because the message is retrievable from context (Hall et al. 2016; 2018). This is discussed in more detail in 1.7.4. For example, listeners could retrieve a lexical message carried by a word when the word is predictable given preceding words. Although probabilistic reduction has been discussed in relation to lexical message predictability, little, if any, work has been carried out on social message predictability. If variation in loanword phonology is socially meaningful, it provides an interesting test case to explore this less familiar predictability effect. The other aim of this thesis is therefore to develop our understanding of *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message* **[RQ1b]**. It will be demonstrated that the production of a variant in loanword phonology is indeed affected by social message predictability in some cases, with the details in Chapters 6 and 7. These findings suggest that predictability effects can be extended to social messages.

In order to address the above two research questions, we will explore loanword phonology in New Zealand English (NZE). More specifically, this thesis discusses variation in /r/ realizations in Māori loanwords, as will be described in 1.5. The /r/ sounds in loanwords are sometimes pronounced by NZE speakers as the native rhotic sounds (e.g. *ko*[ɹ]*u* and *ma*[ɹ]*ae*) and sometimes as non-native rhotic sounds as in te reo Māori (e.g., *ko*[ɾ]*u* and *ma*[ɾ]*ae*). At a theoretical level, addressing the above two questions allows us to increase our understanding of *how variants of loanword pronunciation are stored in the mind of a borrower and processed in production* **[RQ1]**. The hypotheses about this theoretical research question are developed on the basis of Exemplar Theory (Pierrehumbert 2001; 2002) and Message-Oriented Phonology (Hall et al. 2016; 2018), with more detail in 1.7.

The remainder of this chapter reviews previous literature about loanword phonology (Section 1.2), likelihood of adaptation vs. importation (Section 1.3), probabilistic reduction (Section 1.4), and borrowing and loanword phonology in NZE (Section 1.5). Section 1.6 presents the research questions in more detail. Section 1.7 constructs a theoretical framework with hypotheses about representations and processing of loanword pronunciation in the mind of a borrower. On the basis of the theoretical framework, Section 1.8 deduces predictions that offer potential answers to the research questions. Section 1.9 overviews the thesis.

1.2 Loanword phonology: adaptation vs. importation

This section demonstrates that there is variation in the pronunciation of loanwords by reviewing previous literature that describes patterns of loanword pronunciation. When someone borrows a word from a foreign language, the word may contain a sound or structure that is not permitted in the grammar of her own language (i.e., a phonologically ungrammatical structure for the borrowing language). This ill-formed sound or structure is called *non-native structure* (see Paradis & LaCharité 1997; 2011; LaCharité & Paradis 2005). For example, English has a retroflex-coronal /ɹ/, while German does not have this sound. That is, the retroflex-coronal /ɹ/ does not occur in native German, and the segment is a non-native structure for German. To take another example, a word-final consonant cluster like *mètre* [mɛtr] occurs in French while the

phonological structure is not attested in native Fula, and thus a word-final consonant cluster is non-native to Fula.

When a borrower is faced with non-native structure, she may alter the structure into a well-formed one that conforms to the phonology of her own language, or she may adopt the illicit structure without any phonological alternations. The former consequence is called *adaptation*, and the latter is *importation* (Haugen 1950; LaCharité & Paradis 2005; Broselow 2006; Kang 2011; Paradis & LaCharité 2011). LaCharité & Paradis (2005) note that "adaptations are geared to ensuring that the L1 system remains unchanged," and define importation as "attempts to imitate the pronunciation of the L2 words to the best of one's ability" and "attempts to have the L1 phonological system accommodate characteristics of L2." Kang (2011) defines adaptation as "processes to conform to the structural constraints of the borrowing language phonology," and defines importation as "a situation where a structure not attested in native phonology is exceptionally allowed in loanwords." For example, when Fula speakers are faced with the non-native structure of the word-final consonant cluster, they epenthesize a vowel in order to resolve the ill-formed structure: *mètre* [mɛt̲r] → [mɛɛt̲ɛr] (Paradis & LaCharité 1997). This consequence is adaptation, since the ill-formed structure is altered to well-formed structure in the core grammar of Fula. On the other hand, German speakers may adopt an illicit segment [ɹ] in their own language, when they borrow a word including [ɹ] from English, e.g., *story* [stɔ̲ɹi] → [stɔ̲ɹi] (Itō & Mester 2001). This consequence is importation, since the illicit segment [ɹ] is maintained intact despite the fact that it does not occur in the native phonology of German.

In this way, non-native structure may be adapted to native structure or imported without modification, with the result that there may be variation in the pronunciation of a loanword. *Loanword phonology* refers to the area of study about these two consequences. In what follows, we will survey more examples of adaptation and importation to enrich our understanding of loanword phonology.

1.2.1 Adaptation

The goal of this sub-section is to survey some cases in which non-native structure in loanwords is altered into well-formed structure for the phonology of a borrowing language. Most previous literature on loanword phonology focuses on adaptation rather than importation, with the result that a large number of adaptation patterns have been documented. Silverman (1992) discusses the adaptation processes of English loanwords in Cantonese. One of the adaptation patterns is the substitution of /s/ for /ʃ/: the Cantonese phoneme inventory does not include /ʃ/, and it is pronounced as a native phoneme /s/ when loanwords contain this non-native structure, e.g., *show* [ʃoʊ] → [s̲oʊ], *sharp* [ʃa:p] → [s̲ap]. Another type of adaptation process is the deletion of illegal codas. The Cantonese phonology allows only the unaspirated plosives /p, t, k/, nasals /m, n, ŋ/ and approximants /w, j/ to appear in coda positions, and illegal consonants in coda position of loanwords are altered to legal consonants, e.g., *shaft* [ʃæf̲t] → [sɐp̲] and *lift* [lɪf̲t] → [lɪp̲]. There is significant documentation of adaptation patterns of loanwords in other

languages: Indonesian (Cohn 1993); Fula (Paradis 1996); Moroccan Arabic (Paradis & Prunet 2000); Fon (Kenstowicz 2003); Māori (Herd 2005); Hawaiian (Adler 2006); Korean (Davis & Cho 2006); Thai (Kenstowicz & Suchato 2006); Shona (Uffman 2006); Fijian (Kenstowicz 2007):

(1) Other examples of adaptation: non-native structure is altered into well-formed structure

a. Indonesian (Cohn 1993): The native phonology locates main stress on a penultimate syllable. When loanwords have illegal main stress location, the location is moved to a penultimate syllable, e.g., *aerodynamics* [èərəʊdaɪnǽmɪks] → [èrodìnamíka].

b. Fula (Paradis 1996): The native phonology does not tolerate consonant clusters. When loanwords include illegal consonant clusters, they are simplified into simple onsets, e.g., *voyou* [vwaju] → [waju] and *voiture* [vwatyr] → [wati:ri].

c. Morroccan Arabic (Paradis & Prunet 2000): The native vowel inventory does not include nasal vowels. When loanwords include illegal nasal vowels, they are unpackaged into oral vowels plus native consonants, e.g., *assurance* [asyrãs] → [lasɪransˌ].

d. Fon (Kenstowicz 2003): The native consonant inventory does not include a trill /ʀ/. When loanwords have illegal trills, they are altered to native phonemes /l/ or /ʁl/, e.g., *bureau* [bīlô] and *rideau* [ʁlīdô].

e. Māori (Herd 2005): The native consonant inventory does not include sibilants /s, z, ʃ, ʒ/. When loanwords include illegal sibilants, they are altered into native phonemes /h/, e.g., *sheep* [ʃi:p] → [hipi].

f. Hawaiian (Adler 2006): The native consonant inventory does not include coronal plosives. When loanwords include illegal coronal plosives, they are altered into native plosives, e.g., *trap* [kəla:pə] and *spout* [kəpauʔu].

g. Korean (Davis and Cho 2006): The native phonology does not allow fricatives to appear in coda positions. When loanwords have illegal coda fricatives, vowels are epenthesized to modify the non-native structure, e.g., *gas* [k'es'ɨ] and *test* [t^hes$ɨt^h$ɨ].

h. Thai (Kenstowicz & Suchato 2006): The native phonology does not tolerate complex codas. When loanwords have illegal complex codas, the consonants that are not next to a vowel is deleted, e.g., *act* [ʔék] and *camp* [khém].

i. Shona (Uffman 2006): The native phonology does not tolerate any closed syllables. When loanwords have illegal coda consonants, vowels are epenthesized to modify the non-native structure, e.g., *ice* [aizi] and *item* [aitemu].

j. Fijian (Kenstowicz 2007): The native phonology locates main stress on a final heavy syllable, otherwise on the penultimate syllable. When loanwords have illegal main stress location, the location is altered to the well-formed location, e.g., colony [kʊ́ləni] → [kòlóni] and polio [póʊli:oʊ] → [pòlió:].

1.2.2 Importation

In this sub-section, we will survey some cases in which loanwords retain non-native structure that is not allowed in the native lexicon. The non-native structure may include phonotactic patterns, phonemic inventories, and accentual positions. Japanese is a well-known case study. The Japanese lexicon is mainly classified into four strata in terms of etymology: native, Sino-Japanese (i.e., traditional loanwords from China), assimilated foreign and unassimilated foreign. Itō & Mester (1995; 1999) generalized that native words do not include a sequence of a nasal consonant and a voiceless consonant, but Sino-Japanese and western loanwords allow this type of sequence, e.g., *kaNpō* "Chinese herbal medicine" and *aNkā* "anchor"; native and Sino-Japanese words do not include non-geminated [p], but western loanwords allow non-geminated [p], e.g., *pāmanento* "permanent" and *apātomento* "apartment"; most morphemes in the Japanese lexicon do not allow voiced geminates, but only unassimilated loanwords include voiced geminates,[1] e.g., *doggu* "dog" and *heddo* "head." In this way, loanwords in the Japanese lexicon may retain non-native structure that is not attested in native vocabulary. It has been reported in many other languages that loanwords retain non-native structure without modification: Russian (Holden 1976); Fula (Paradis 1996), Huave (Davidson & Noyer 1997), Jamaican Creole (Itō & Mester 2001), Fon (Kenstowicz 2003), Hawaiian (Adler 2006), Selayarese (Broselow 2009), Thai (Kenstowicz & Suchato 2006); Hebrew (Lev-Ari & Peperkamp 2014); Québec French (Hsu & Jesney 2016) among others:

(2) Other examples of importation: non-native structure is allowed in loan vocabulary

a. Russian (Holden 1976): Only palatalized consonants are allowed to occur before stressed /e/ in native vocabulary, but non-palatalized consonants may be allowed to occur in loanwords, e.g., *deféktnyj* [dyfʲéktnyj] "defective."

b. Fula (Paradis 1996): The native consonant inventory does not include voiced fricatives, but loanwords may tolerate /z/, e.g., *buuzi* "candle" and *zanviye* "January."

c. Huave (Davidson & Noyer 1997): The word-final closed syllable is always stressed in native vocabulary, e.g., *taraŋás* "I did," but word-final closed syllables can be unstressed in loanwords, e.g., *mjérkoles* "Wednesday."

d. Jamaican Creole (Itō & Mester 2001): The native phonology does not include any consonant clusters, but loanwords may tolerate consonant clusters, e.g., *stick* [stɪk]; the native consonant inventory does not include dental fricatives [ð], but loanwords may tolerate them, e.g., *that* [ðat].

e. Fon (Kenstowicz 2003): The native phonology does not include a sequence of an oral consonant plus a nasal vowel, but loanwords may allow this type of sequence, e.g., *bandit*

[1] As explained in the following section, it is assumed for simplicity that Japanese speakers perceive *dog* and *head* as [doggu] and [heddo] respectively due to the perceptual illusion (Kaneko and Iverson 2009). Given that these perceptual forms are inputs to borrowers, the voiced geminates such as [gg] and [dd] could be regarded as non-native structure.

[bãdĭ] and *banc* [bã].

f. Hawaiian (Adler 2006): The native consonant inventory does not include coronal plosives, but loanwords may tolerate a coronal plosive /t/, e.g., *truck* [təlákə].

g. Thai (Kenstowicz & Suchato 2006): The native phonology does not allow coda fricatives, but loanwords may tolerate coda fricatives, e.g., *bus* [bás] and *disk* [dís].

h. Salayarese (Broselow 2009): Native words always have penultimate stress, but loanwords may allow antepenultimate stress, e.g., *lámbere* "long" and *maŋkásara* "Makassar."

i. Hebrew (Lev-Ari & Peperkamp 2014): The native consonant inventory does not include affricates [dʒ], but loanwords may include an affricate, e.g., *gentleman* [dʒentelman].

j. Québec French (Hsu & Jesney 2016): The native consonant inventory does not include affricates [tʃ], but loanwords may include an affricate, e.g., *lunch* [lɔntʃ] and *batch* [batʃ].

1.3 Likelihood of adaptation vs. importation

As was reviewed in the last section, there is a large body of research about adaptation and importation of non-native structure in loanwords. This section reviews previous literature that discusses why loanwords are sometimes pronounced with imported structure and why they are sometimes pronounced with adapted structure.

Generative phonologists have offered theoretical accounts for these two phenomena in the framework of Optimality Theory (Prince & Smolensky 1993/2004; Kager 1999; McCarthy 2002; 2008) in a variety of ways, e.g., by stipulating a general phonological system and a loanword-specific phonological system using indexed faithfulness constraints (Itō & Mester 1999; 2001), cue constraints (Boersma 2009), or by weighted scalar constraints (Hsu & Jesney 2014). For example, Itō & Mester (1999) demonstrate that the difference between adapted forms and imported forms can be captured by positing that adapted loanwords and imported loanwords obey different faithfulness constraints. As was seen in 1.2.2, voiced geminates are not attested in the native vocabulary of Japanese, and thus they can be regarded as non-native to Japanese phonology. Some loanwords conform to this phonotactic restriction and voiced sounds in inputs are adapted to voiceless sounds (e.g., *bag* → *bakku* "bag"). On the other hand, some loanwords violate this restriction, and voiced geminates are retained and imported without modification (e.g., *dog* → *doggu* "dog"). For simplicity, it is assumed that Japanese speakers perceive *bag* and *dog* as [baggu] and [doggu] respectively due to perceptual illusion (Kaneko & Iverson 2009). This variation is captured by postulating that different faithfulness constraints are associated with assimilated loanwords and unassimilated loanwords. More specifically, unassimilated loanwords obey a faithfulness constraint ranked above a markedness constraint against voiced geminates, whereas assimilated loanwords obey a faithfulness constraint ranked below the markedness constraint. The perceptual forms are considered as inputs in the following tableaux.

(3) Account for adaptation and importation in Optimality Theory

a. Constraint inventory

NO-DD: Assign one violation mark for a voiced geminate.

FAITH (assimilated): Assimilated loanwords are faithful to the value of input [voice]

FAITH (unassimilated): Unassimilated loanwords are faithful to the value of input [voice]

b. Ranking demonstration

i. Assimilated loanwords: *bag* → *bakku*

Input: baggu	FAITH (unassimilated)	NO-DD	FAITH (assimilated)
baggu		*!	
☞ bakku			*

ii. Unassimilated loanwords: *dog* → *doggu*

Input: doggu	FAITH (unassimilated)	NO-DD	FAITH (assimilated)
☞ doggu		*	
dokku	*!		

Although these approaches can describe adaptation and importation by stipulating different co-grammars and lexical indexicality, they do not predict when loanwords are adapted and when loanwords are imported. That is, they do not consider factors external to phonology that might influence the likelihood of adaptation vs. importation.

Beyond generative phonology, there are a certain number of studies about factors governing adaptation versus importation, e.g., level of bilingualism (Haugen 1950; Friesner 2009; Lev-Ari et al. 2014; Aktürk-Drake 2015; 2016); degree of linguistic integration (Haugen 1950; Poplack & Sankoff 1984; Poplack et al. 1988); age and social class (Friesner 2009; 2010); prestige in semantic domain (Lev-Ari & Peperkamp 2014; Lev-Ari et al. 2014); language dominance (Aktürk-Drake 2015; 2016). In what follows, we will review three main factors that are related to the current study in more depth (bilingualism, word frequency, and prestige in semantic domain).

The level of bilingualism is reported to strongly affect the likelihood of adaptation vs. importation (Haugen 1950; Poplack et al. 1988; Friesner 2009; Lev-Ari et al. 2014; Aktürk-Drake 2015; 2016). Lev-Ari et al. (2014) classify bilingualism into three types: individual bilingualism, neighbourhood bilingualism, and interaction bilingualism. Individual bilingualism refers to borrowers' proficiency in the source language. Previous literature shows that borrowers with higher fluency in the source language are more likely to import non-native structure and those with lower fluency in the source language are more likely to adapt non-native structure into native structure. For example, Friesner (2009: 118) reports that French speakers who can speak English fluently import retroflex coronal approximants at a rate of 77% whereas those who cannot speak English well import the non-native sounds only at a rate of 34%. Aktürk-Drake (2015; 2016) studied western loanwords into Turkish and statistically

demonstrates that non-native structure is 36.5 percentage points more likely to be imported in Sweden, in which speakers become early Turkish-Swedish bilinguals, than in Turkey, in which speakers become late Turkish-English bilinguals. Neighbourhood bilingualism refers to that of a community to which a borrower belongs and previous literature shows that higher levels of neighbourhood bilingualism may incur higher rates of importation. Poplack et al. (1988) studied English loanwords in French by collecting data from five major francophone bilingual communities in the Ottawa-Hull region. They found that borrowers are more likely to import English non-native structure in a community with a larger number of residents who can speak English, and they claim that neighbourhood bilingualism plays a greater role in the rate of importation than individual bilingualism. Similarly, Lev-Ari et al. (2014) demonstrate that Mexicano borrowers with higher neighbourhood bilingualism are more likely to import Spanish non-native sounds such as trills and voiced plosives, and neighbourhood bilingualism has more significant effects on the likelihood of importation than individual bilingualism. Contrary to these studies, Friesner (2009) studied English and Spanish loanwords in French and found that neighbourhood bilingualism is less predictive of importation rate than individual bilingualism, and that even when it shows a significant effect, the direction is opposite; that is, importation rates are higher in a community with a lower level of bilingualism. Interaction bilingualism is discussed only by Lev-Ari et al. (2014) and it refers to the interlocutor's bilingualism. They hypothesized on the basis of Accommodation Theory (Giles et al. 1991) that "when faced with an interlocutor with a low level of bilingualism who cannot produce or perceive foreign sounds faithfully, a highly bilingual speaker might accommodate by adapting these foreign sounds as well." They found that Mexicano borrowers are more likely to adapt Spanish non-native structure when they speak with interlocutors with lower levels of bilingualism.

Word frequency is also reported to influence the likelihood of adaptation vs. importation. Haugen (1950: 216) notes that "if he has occasion to repeat it, or if other speakers also take to using it, a further substitution of native elements will take place." That is, as loanwords are used more frequently, their non-native structure is more likely to be adapted to native structure. In fact, Poplack & Sankoff (1984) and Friesner (2009; 2010) also demonstrate that high frequency loanwords are more likely to be adapted than low frequency loanwords. Contrary to these studies, Lev-Ari et al. (2014) show that this effect is not supported in their dataset collected in Spanish-Mexicano bilingual communities. However, their word frequency was subjectively rated by one of the authors, and they note that "since our measures of individual bilingualism and word frequency were relatively coarse as well as subjective, it is unclear whether they play no role in sound adaptation or whether our measurements were not sensitive enough to capture their role."

Finally, Lev-Ari & Peperkamp (2014) and Lev-Ari et al. (2014) demonstrate that the prestige of a source language in a loanword's semantic domain increases the likelihood that non-native structure in the loanword is imported. Lev-Ari & Peperkamp (2014) ran an experiment using the Go Fish game, and demonstrate that French speakers are more likely to

import a non-native affricate [ʤ] in a novel Italian word *Genna* when the loanword refers to ice cream, for which Italy is renowned, whereas they are more likely to adapt the non-native sound to a native fricative [ʒ] when the loanword refers to beer, for which Italy is not famous. Lev-Ari et al. (2014) documented the pronunciation of loanwords from Spanish to Mexicano, and they found that speakers are more likely to import non-native sounds in loanwords describing high-technology and commerce, for which the source language Spanish is prestigious.

Despite these previous studies, it is still largely unknown what exactly determines the likelihood of adaptation vs. importation. The effects of sociolinguistic factors on variation in loanword adaptation are especially unexplored, as Friesner (2009: 9) notes "Although several authors refer to the relevance of social factors as predictors of the outcome of borrowing, few studies address this issue directly," and Lev-Ari & Peperkamp (2014) also note that "Despite the wide agreement that social factors can influence sound change, this question has not been examined in relation to sound adaptation in loanwords." As will be stated in 1.5, one aim of this thesis is to examine the effects of some unexplored sociolinguistic factors on the likelihood of adaptation vs. importation, thereby increasing our understanding of *the extent to which the selection of adapted structure vs. imported structure is influenced by sociolinguistic factors* [RQ1a]. Chapters 3-5 provide further evidence that the likelihood of adaptation vs. importation is governed by some sociolinguistic factors (e.g., topic in speech, and speakers' and words' association with a source language and its culture), and that variation in loanword phonology is socially meaningful.

1.4 Redundancy in linguistic signal: probabilistic reduction

As noted in 1.1, our interest also lies in the realization of a linguistic unit. In this section, we review previous studies that discuss the relationship between the realization of a linguistic unit and predictability. Some segments of speech may be clearer and hyper-articulated, while the other parts may be more ambiguous and hypo-articulated. For example, a /t/ sound is fully articulated and aspirated in word-initial position (e.g., *t̲ime*), while it is not well-articulated and even deleted in word-final position (e.g., *fas̲t*). It is well-known that more predictable linguistic units tend to be produced with reduced signals (see Hall et al. 2016; Jaeger & Buz 2017; Shaw & Kawahara 2018 and their citations). In an oral language, reduced signals refer to speech sounds with low levels of articulatory and acoustic redundancy such as shorter segments and centralized vowels (Aylett & Turk 2006). This predictability-based reduction is called *probabilistic reduction*. Probabilistic reduction has been discussed at a variety of linguistic levels such as words, morphemes, syllables, and segments.

The most well-discussed predictability effect is at the word level (Bybee 2001; Jurafsky et al. 2001; Bell et al. 2003; 2009; Baker & Bradlow 2009; Baker et al. 2011; Seyfarth 2014; Pate & Goldwater 2015; Sóskuthy & Hay 2017). These studies demonstrate that words with higher predictability are produced with reduced signals, that is, shorter duration. For example, words

with higher word frequency (i.e., higher paradigmatic predictability) are known to be produced with shorter duration. Jurafsky et al. (2001) show that high frequency words are produced with 18% shorter signals in comparison to low frequency words in spontaneous speech. The effect of word frequency on duration or reduction is also observed in a passage-reading task (Baker & Bradlow 2009; Baker et al. 2011) and even in a word-list reading task (Wright 1979; Munson 2007). To take another example, it is also known that words with higher contextual predictability are produced with shorter duration. Jurafsky et al. (2001) demonstrate that words with higher predictability given a preceding word and a following word are produced with shorter duration. Similarly, it has been demonstrated that the number of times being mentioned affects the duration of words. Fowler & Housum (1987) show that the second mention tends to be shorter and less intelligible in comparison to the first mention when English speakers repeat a word in a conversation. These findings about syntagmatic predictability effects are also replicated in a passage-reading task (Baker & Bradlow 2009; Baker et al. 2011).

Some previous literature discusses probabilistic reduction at other linguistic levels such as morphemes (Cohen 2014; Rose 2017) and syllables and segments (van Son & Pols 2003; Aylett & Turk 2004; 2006; Cohen-Priva 2012; 2015; Shaw & Kawahara 2017). For example, Rose (2017) demonstrates that a plural /s/ morpheme is likely to be produced with shorter duration when it is more predictable given a preceding word such as *two* or *several*. Aylett & Turk (2006) show that syllables with higher contextual predictability given surrounding syllables are produced with shorter duration in spontaneous speech, and contextually predictable vowels are centralized in their articulation. Cohen-Priva (2012; 2015) shows that consonants are more likely to be deleted when they are predictable given surrounding segments.

For the purpose of this thesis, probabilistic reduction is discussed using a message-oriented approach (for other probabilistic approaches to reduction see review by Jaeger & Buz 2017). The message-oriented approach hypothesizes that the linguistic system is subject to at least two biases: a bias for maximizing the accuracy of message transmission and a bias for minimizing the resource cost expended for signal production. These two biases usually conflict with each other, and thus a speaker is required to balance these two biases to promote effective message transmission. The transmission of a message carried by a predictable linguistic unit is potentially accurate, because the message could be retrieved easily from context. Hence, a speaker could produce a less costly signal for the predictable message while keeping the probability of accurate message transmission sufficiently high. For example, lexical messages carried by contextually predictable words could be retrieved without hyper-articulated signals. Similarly, it should be easier to identify words, that is, retrieve lexical messages given segments or syllables with higher contextual predictability. As a result, speakers could minimize the resource cost for the production of words, syllables, and segments with higher contextual predictability, while ensuring successful lexical message transmission. This message-based approach will be reviewed in 1.7.4 in more detail.

The above cited studies about probabilistic reduction are all relevant to the predictability

of lexical (or morphological) messages. However, message transmission in speech involves a variety of messages. Speakers could express their social identity (Tajfel 1978; Le Page & Tabouret-Keller 1985), that is, their geographical and social origins, their social relationship with the listener and the community, and their social status as social messages. Social messages could be expressed by choosing a variant of sociolinguistically meaningful variable (Eckert 2005; 2008). As reviewed in 1.1, speakers of American Southern English may express "formality" and "intelligence" by choosing a velar variant of a ING-morpheme whereas they may express a lack of these properties by choosing an apical variant. To the best of our knowledge, probabilistic reduction has yet to be discussed in relation to social message predictability, although Foulkes et al. (2018) point out that signal reduction may be influenced by some sociolinguistic factors such as age and gender. It is this research gap that motivates the second goal of the current thesis. As will be seen below, we will hypothesize that loanword phonology is affected by sociolinguistic factors, and that variation is socially meaningful. That is, the variants in the production of loanwords, adapted structure and imported structure, are hypothesized to carry different social messages. Given that this hypothesis is well-supported in the current study, variation in loanword phonology provides an interesting test case to explore the effect of social message predictability on signal reduction. This is the other purpose of this thesis, and we will develop our understanding of *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message* [RQ1b]. Chapters 6 and 7 provide partial evidence that the realization of a sociolinguistically meaningful variant is affected by the importance of the social message. These findings suggest that predictability effects could be extended to social messages to some extent.

1.5 Loanword phonology in New Zealand English

In order to address the research questions [RQ1a] about the likelihood of adaptation vs. importation and [RQ1b] about redundancy in a variant in loanword phonology, we will explore loanword phonology in NZE, which provides an interesting test case for our research questions. One reason for choosing NZE loanword phonology as a test case is that Māori loanwords are widely used in NZE as the interaction of the two languages is very strong. New Zealanders are exposed to Māori words every day, because many public signs are written in te reo Māori as well as English, and they know a number of Māori words, as reviewed in 1.5.1. The other reason is that there is variation in the pronunciation of Māori loanwords. The loanwords are sometimes pronounced in a way that is near to the original Māori pronunciation and they are sometimes pronounced with native English phonology, as reviewed in 1.5.2.

This section reviews previous literature about loanwords from te reo Māori to NZE in 1.5.1 and NZE loanword phonology in 1.5.2. This review section enriches our understanding of how the two languages have interacted over time. On the basis of the literature review, Section 1.5.3 identifies which adaptation and importation patterns are discussed in this thesis.

1.5.1 Borrowing in NZE

The goal of this sub-section is to enrich our understanding of borrowing in NZE. It is believed that the first explorers to New Zealand were Polynesian people, currently known as Māori, and that their arrival was about 1,000 years ago. In the 19th Century, a large number of European people, mainly from Britain, started immigrating to New Zealand. Their descendants are called Pākehā. Accordingly, New Zealand has two major spoken languages, te reo Māori and English. These two languages have been in contact with each other since the late 18th century. Albury (2016) divides their interaction into three periods: colonial tolerance, language shift, and language revitalization. In the first period (late 18th century to mid-19th century), British missionaries were likely to become English and Māori bilinguals, and they brought literacy to the Māori. In the second period (mid-19th century to 1970s), British nationalism inspired policies to anglicize the Māori language and community. During this period, te reo Māori was eradicated from schools and language shift to English occurred. However, from the second half of the 20th century, indigenous policy was totally changed in New Zealand, and the government started to facilitate and protect the Māori language as a response to protests and initiatives of the Māori community. This is the third period (1970s to today). Te Puni Kōkiri (2006) estimates that one percent of non-Māori people are able to speak te reo Māori, and Te Kupenga (2013) shows that about 25% of Māori people are able to speak te reo Māori.

Throughout the history of New Zealand, a great number of Māori words have been borrowed into English in New Zealand. Previous literature (Deverson 1984; 1991; Macalister 2004; 2005; 2006a; 2006b; 2007; Davies & Maclagan 2006) argues that the presence of Māori words has been growing since the 1970s. Macalister (2007) notes "previous estimates of an average New Zealand English speaker's Maori word vocabulary (other than proper names) at 40-50 words (Gordon & Deverson 1998) have been too conservative and should be revised upwards, to the 80-90 word range." We could find approximately 800 entries of Māori loanwords in *The New Zealand Oxford Dictionary* (Deverson & Kennedy 2005), about 170 of which have anglicized pronunciations according to my count, and there are approximately 950 entries in a dictionary that focuses on Māori loanwords (Macalister 2005). These facts suggest that many Māori loanwords have been incorporated into NZE, and the type frequency is increasing. Davies & Maclagan (2006) show that Māori loanwords related to culture and society have increased in token frequency, whereas the other words remain steady in token frequency. Familiarity with Māori loanwords may vary depending on the speakers. The surveys by Macalister (2004; 2006a; 2006b; 2007a) show that familiarity with Māori words can differ in accordance with gender, age, and meaning: females show greater familiarity with Māori loanwords; those who identify as Māori show greater familiarity with Māori loanwords; older people know more Māori loanwords. Calude et al. (2017) quantitatively explore the usage of Māori loanwords in NZE using a larger dataset than the other studies. They found that a Pākehā speaker is more likely to use a Māori loanword when there is no corresponding word in English, when the loanword contains a smaller number of segments, when the loanword refers to Māori

culture, and when the loanword is a content word.

1.5.2 Pronunciation of Māori loanwords in NZE

Next, we would like to review literature about the pronunciation of Māori loanwords. The phonological systems of te reo Māori and NZE are very different. The Māori vocalic system has five short vowels /i, e, a, ɔ, u/ and five long vowels /i:, e:, a:, ɔ:, u:/ (Biggs 1961; Bauer 1993). It is still controversial which vowel sequence is regarded as a diphthong or a hiatus (Harlow 2007: 69). On the other hand, NZE has 11 monophthongs /ɪ, æ, e, ɒ, ʌ, ʊ, i:, a:, ɔ:, u:, ɜ:/ and 8 diphthongs /iə, eə, aʊ, ei, oʊ, ai, ɔi, ʊə/ as well as reduced vowels (Bauer & Warren 2008; Hay et al. 2008). The two consonantal systems are also different. The Māori consonant inventory includes ten phonemes /p, t, k, m, n, ŋ, f, h, ɾ, w/, whereas the NZE inventory has a larger set of phonemes as in other varieties of English. The most salient difference in the two consonantal systems is the rhotic phoneme. Māori has a tap sound /ɾ/ for its rhotic phoneme, whereas NZE has an approximant /ɹ/ for its rhotic phoneme. As for the other consonants, the acoustic properties may be different to some extent in the two languages, even if the phonological categories are identical.

As the two sound systems are different, Māori loanwords undergo adaptation to different degrees when they are borrowed and produced by NZE speakers. The adaptation patterns observed in Māori loanwords have been discussed by a small number of studies (Matthews 1984; Deverson 1988; Deverson & Kennedy 2005: XI; Bauer & Warren 2008: 57-59; Hay et al. 2008: 72-74). Bauer & Warren (2008: 57-59) offer the most detailed descriptive generalization about how Māori sounds are mapped onto NZE sounds. They divide NZE speakers into two extreme positions, an assimilationist position and a nativist position. Assimilationists refer to those who pronounce Māori loanwords in the way of English, whereas nativists refer to those who pronounce Māori loanwords in a way that is as near to the original Māori pronunciation as possible. They generalized the adaptation of Māori vowels in accordance with the two positions using the vowel taxonomy developed by Wells (1982). Table 1.1 illustrates the descriptive generalization.

Māori vowel	Short vowels		Long vowels	
	Nativist	Assimilationist	Nativist	Assimilationist
i	KIT	KIT	FLEECE	FLEECE
e	DRESS, FACE/_#	DRESS, *happ*Y/_#	FACE	FACE
a	STRUT	TRAP	START	START
ɔ	LOT	LOT	THOUGHT	GOAT
u	FOOT	FOOT, STRUT	GOOSE	GOOSE

Table 1.1 Typical mapping of Māori vowels to NZE vowels (Bauer & Warren 2008)

As for consonants, they note "most Māori consonants have obvious and fixed correspondents in English although this has not always been so." Previously, Māori /p, t, k/ were sometimes mapped onto NZE /b, d, g/, and Māori /ɾ/ was sometimes mapped onto /d/. Nowadays, they are consistently mapped onto /p, t, k, r/ respectively. Māori /ŋ/ is variably reproduced as /ŋ/ or /ŋg/ in morpheme-internal position. They note that nativists are more likely to pronounce /ŋ/ whereas assimilationists are more likely to pronounce /ŋg/. That is, /ŋg/ is a more English-assimilated variant than /ŋ/. This velar nasal is consistently mapped onto a coronal nasal /n/ in word-initial position. Māori /f/ written as <wh> is often reproduced as NZE /f/, but it was sometimes pronounced as /ʍ/. The other Māori consonants /m, n, w, h/ are consistently mapped onto the NZE consonants /m, n, w, h/.

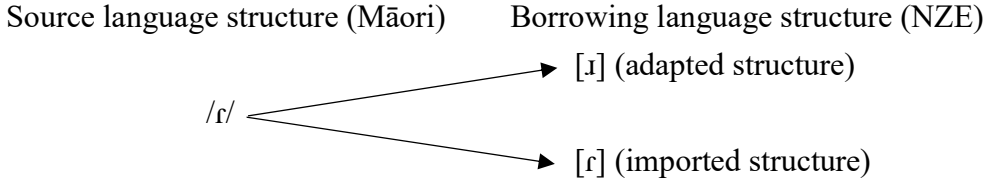
In addition to these adapted structures, imported structures are also observed especially in the speech of a younger NZE speaker, who may have an opportunity to learn te reo Māori at an primary school even if she cannot speak te reo Māori fluently as a second language (Albury 2016). Note that, in the case of NZE loanword phonology, imported structure refers to structure that maintains phonological structure that is tolerated in the source language te reo Māori but is not attested in the borrowing language NZE. This assumption is supported by the observation of previous literature: "Maori pronunciations are also heard (Bauer & Warren 2008: 58)" and "Younger people are more likely to use the Maori pronunciation (Hay et al. 2008: 74)," see also de Bres (2010). When we check SNS such as facebook and twitter, we can find that many New Zealanders discuss the correct pronunciations of Māori words, and many of them try to pronounce Māori loanwords in the way as near to the original Māori pronunciation as possible, that is, by employing imported structure.

1.5.3 Target non-native structure in this study

The aim of this sub-section is to identify which non-native structure in Māori loanwords is discussed in the current thesis. As is reviewed above, te reo Māori and NZE have different phonological systems. Hence, when words are borrowed from te reo Māori to NZE, the words may include non-native structure, which is sometimes imported without modification and sometimes adapted to native structure. For simplicity, the current study focuses on the non-native structure /ɾ/, in order to discuss the NZE loanword phonology. As was discussed above, the Māori rhotic sound can be regarded as non-native to NZE speakers, since the tap is Māori's rhotic phoneme, whereas English has an approximant for its rhotic phoneme. As will be acoustically identified in Chapter 3, this non-native rhotic sound may be adapted to a native rhotic sound [ɹ], or may be imported and produced as [ɾ] in the production of Māori loanwords by NZE speakers (see also Maclagan & King 2005). The reason for choosing this variable to study is threefold: (i) the distinction of imported [ɾ] and adapted [ɹ] is acoustically clear, allowing us to secure the objectivity of classification, (ii) this variation is salient even for NZE speakers without linguistic knowledge, and (iii) there is a large enough number of loanwords with /r/ that are frequently heard in daily life. For convenience, we assume that the imported

structure [ɾ] is cognitively different from a flapped variant of /t/ to NZE speakers. The reason is that NZE speakers do not seem to have an intuition that the Māori rhotic sound is similar to the flapped /t/ variant, and some NZE speakers even call the non-native rhotic "rolled-r" or "Māori-r." That is, NZE speakers do not relate imported [ɾ] with a coronal plosive /t/ consciously. As the current study focuses on this variable, the term "imported structure" refers to Māori rhotic sounds or tap sounds [ɾ], and "adapted structure" refers to English rhotic sounds or approximants [ɹ] throughout this thesis, unless specifically mentioned.

(4) Variable under study in this thesis



Before concluding this section, we would like to mention another non-native structure. Although round vowels cannot follow labial fricatives and approximants /*fɔ, *fu, *wɔ, *wu/, there are no other categorical phonotactic restrictions regarding consonant-vowel sequences in te reo Māori (Hohepa 1967: 6; Bauer 1993: 542-548, Harlow 2007: 69-71). That is, all short vowels can occur word-finally: *kiki* 'kick,' *keke* 'cake,' *kaka* 'garment,' *koko* 'shovel,' and *kuku* 'mussel.' On the other hand, short full vowels /ɪ, æ, e, ɒ, ʌ, ʊ/ cannot occur in word-final position in English (RP: Gimson 1970: 9.09; Wells 1982: 119; American English: Chomsky & Halle 1968: 74; Hammond 1999: 108). That is, Māori allows short vowels to appear word-finally whereas English does not allow short full vowels to appear in word-final position. Hence, word-final short full monophthongs /i#, e#, a#, ɔ#, u#/ could also be regarded as non-native to NZE. As will be noted in Chapter 4 (Experiment 2), we originally planned to explore the realization of /ɔ#/ in the production of Māori loanwords by NZE speakers, and we expected that this non-native structure is adapted to GOAT vowels or THOUGHT vowels, which are allowed to appear word-finally in English and have acoustic values similar to Māori /ɔ#/. In Experiment 2, NZE speakers pronounced a certain number of loanwords ending with /ɔ/ and native words including three native vowels (GOAT, THOUGHT, and LOT). We explored the /ɔ/ realizations in the loanwords by plotting F1 values and F2 values of these vowels at the 20% and 80% timepoints. It was found that, according to the vowel plots, /ɔ#/ is usually adapted to GOAT vowels, while it is sometimes adapted to THOUGHT vowels, as expected. In our dataset, it seems that /ɔ#/ is rarely realized as a LOT vowel in word-final position, contrary to the generalization of the previous literature, see Table 1. This is unsurprising because LOT vowels are not allowed to appear word-finally in the native phonology of English. The vowel plots in Figure 1.1 show typical cases. The y-axis and x-axis represent F1 values and F2 values respectively, and the trajectories go from the formant values at the 20% timepoints to those at the 80% timepoints. The axes are reversed so that the plots look like vowel spaces. The light-blue line represents the

realization of /ɔ#/ in a particular Māori loanword, the red lines represent formant trajectories of GOAT, the purple lines represent those of THOUGHT, and the green lines represent those of LOT. The left-hand plot represents the vowel trajectory of the word-final vowel in *pukeko* and several native vowel tokens produced by Participant 25. As is clear, the trajectory of /ɔ#/ is similar to those of GOAT vowels. Similarly, the right-hand figure represents the trajectory in *moko* produced by Participant 24, and this trajectory is similar to those of THOUGHT vowels.

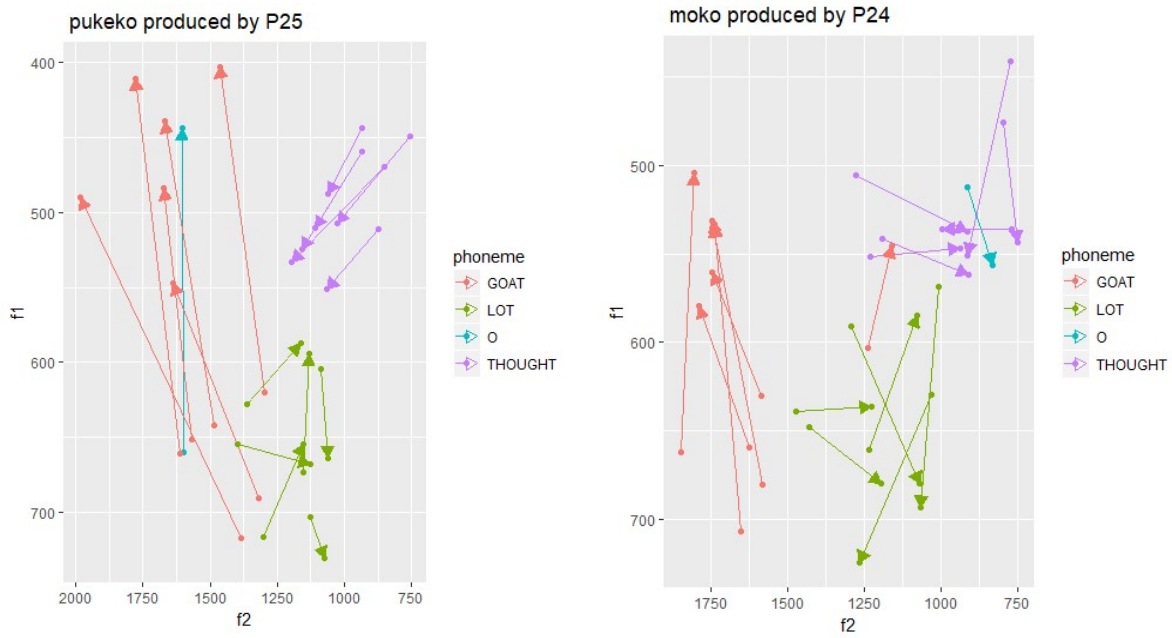


Figure 1.1 Vowel trajectories in /ɔ#/ and native vowels

However, it was found that the realizations of /ɔ#/ in Māori loanwords are not always clear to classify into English vowels. The following two plots show ambiguous cases. In the case of the left-hand token, the formant area of /ɔ#/ is similar to those of THOUGHT vowels, but the trajectory goes in the opposite direction from those of THOUGHT vowels. In the case of the right-hand token, /ɔ#/ begins with a formant value similar to THOUGHT vowels, but it ends with a very different formant value. These realizations of /ɔ#/ seem to have different formant features from other native vowels. This might suggest that NZE speakers import Māori vowels rather than adapt them to native vowels. That is, the realizations of vowels in Māori loanwords have more diverse nature than we expected. This is an interesting fact, but our data has only about 600 realizations of /ɔ#/ in a limited set of Māori loanwords, which may not allow us to explore the various nature of realization of /ɔ#/. The adaptation and importation of vowels in Māori loanwords are therefore left for future study using a larger dataset.

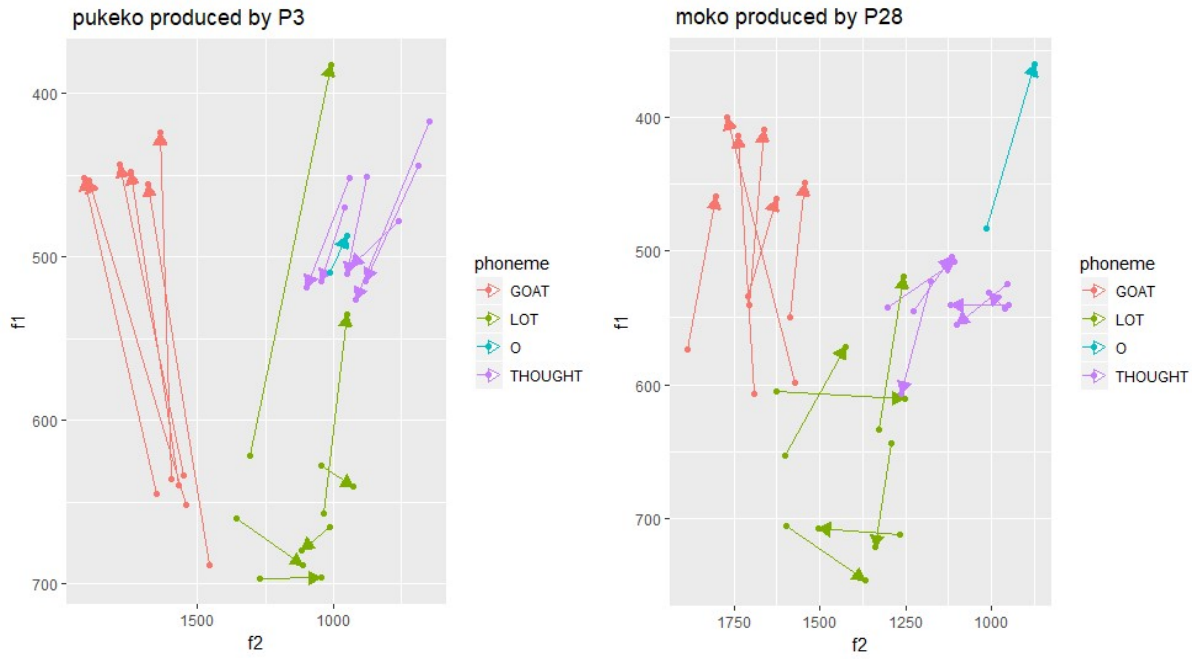


Figure 1.2 Ambiguous realizations of /ɔ#/ in production of Māori loanwords

1.6 Research questions

This section states the research questions addressed in this thesis in more detail. As noted in 1.1, the interest of this thesis lies in the production of loanwords in speech. Investigating loanword production will inform our understanding of how variants in loanword phonology (i.e., adapted structure and imported structure) are represented and processed in a borrower's mind. This is the overarching research question of this thesis:

RQ1: "How are imported structure and adapted structure stored in the mind of a borrower and processed in the production of a loanword?"

Hypotheses about this question will be presented in the next section, by constructing a theoretical framework based on previous literature. The hypotheses will be tested by exploring the two concrete research questions (RQ1a and RQ1b) in relation to the above literature review:

RQ1a: "To what extent is the selection of a variant in loanword phonology influenced by sociolinguistic factors?"

RQ1b: "To what extent is the production of a variant in loanword phonology affected by the predictability of the social message?"

In what follows, we will discuss these two concrete research questions (RQ1a and RQ1b) further in detail, and offer more specific research questions.

1.6.1 Likelihood of adaptation vs. importation

This sub-section aims to discuss the research question [RQ1a] about the likelihood of adaptation vs. importation more specifically. As reviewed in 1.3, previous literature has demonstrated that the rate of adaptation and importation is influenced by several factors. However, it is still less clear what exactly determines the likelihood of adaptation versus importation of non-native structure. As Lev-Ari & Peperkamp (2014) note "Despite the wide agreement that social factors can influence sound change, this question has not been examined in relation to sound adaptation in loanwords," the effects of sociolinguistic factors on the variation in loanword adaptation are especially unexplored. The first aim of the current study is to explore the possibility that variation in loanword phonology reflects more general principles observed in sociolinguistic variation, that is, *to what extent the selection of a variant in loanword phonology is influenced by sociolinguistic factors* [RQ1a]. More specifically, our interest lies in social information indexed to a loanword, that is, the source language and its culture.

First, RQ1a will be addressed by examining whether the selection of adapted structure or imported structure is a type of intra-speaker variation. Previous literature has shown that intra-speaker variation is sensitive to many elements of the speech situation (Mendoza-Denton 1999) such as audiences in speech and topics in speech. Topic effects are well attested in the literature on sociolinguistic variation, as discussed in detail in 3.2.2. For example, Rickford & McNair-Knox (1994) found that an African-American teenager chose different variants depending on whether the topic in speech was school-related or not. Topic effects have not, to our knowledge, been discussed in relation to loanword phonology. This research gap motivates the following specific question:

RQ2: "Is the likelihood of adaptation vs. importation affected by topic in speech?"

In Chapters 3 and 5, we will explore the idea that the likelihood of choosing adapted structure [ɹ] and imported structure [ɾ] changes depending on whether a topic of speech is associated with the source language and its culture, that is, Māori.

The current thesis also explores another situation-specific sociolinguistic factor, namely cultural images. The effects of cultural images have been discussed only by Hay & Drager (2010), and they demonstrated that female NZE speakers shifted their perception towards vocalic variants of a New Zealand dialect and an Australian dialect in accordance with a kiwi bird stuffed toy (i.e., New Zealand cultural image) and a kangaroo stuffed toy (i.e., Australian cultural image), as discussed in detail in 4.2.2. To the best of our knowledge, this effect has not been explored in relation to speech production, and the current thesis aims to test whether this effect extends to the production of a variant in loanword phonology:

RQ3: "Is the likelihood of adaptation vs. importation affected by cultural images?"

In Chapters 4 and 5, this thesis will explore the possibility that the likelihood of choosing adapted structure [ɹ] and imported structure [ɾ] changes depending on whether a borrower sees a cultural image associated with Māori. The degree of consciousness to a presented image may be less explicit in comparison to a topic in speech, because the exposure to a cultural image is subtle and it is not exactly a part of a speech act. Hence, the exploration of the two situation-specific sociolinguistic factors allows us to increase our understanding of to what extent the selection of a variant in production is affected by different degrees of consciousness of social information.

According to Bell (1984; 2001), intra-speaker variation is always based on inter-speaker variation, which is sensitive to speakers' social identities. Speaker-specific sociolinguistic properties are well-known to play important roles in socio-linguistic variation (see the literature review in 3.2.2), and we will explore whether these sociolinguistic effects extend to variation in loanword phonology. As reviewed in 1.3, the effect of speakers' relationship with a source language and its speakers has been discussed in previous literature about loanword phonology. As will be discussed in Chapter 2, the current study aims to explore broader aspects of speakers' properties, in comparison to the previous literature, such as attitudes towards a source language and its culture, and relationship with the language and culture:

RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"

Chapters 3-5 will explore the relationship between importation rate and speakers' association with Māori.

If we find that the likelihood of adaptation vs. importation is affected by situation-specific and speaker-specific sociolinguistic factors, then we could conclude that variation in loanword phonology is a type of sociolinguistically meaningful variation, because it has been demonstrated that inter-speaker and intra-speaker sociolinguistic variation conveys particular social messages associated with particular social groups or values (Bell 2014: 270-271; Eckert 2016). That is, addressing the above three questions allows us to argue that imported structure [ɾ] and adapted structure [ɹ] carry different social messages.

Additionally, the current thesis explores word-specific sociolinguistic factors (i.e., a loanword's association with a source language and its culture). The effects of word-specific sociolinguistic factors on linguistic variation have been discussed in a small number of studies (Walker & Hay 2011; Hay & Foulkes 2016), with more detail in 3.2.2. For example, Walker & Hay (2011) ran a lexical decision task in two voices (a young voice vs. an old voice), and demonstrate that words associated with elder people (i.e., words used more often by elder people) were recognized by NZE speakers faster and more accurately when the voice was old.

That is, the social information (i.e., age) of a word affects perception of that word. The effect of a loanword's association with a source language and its culture is largely unknown in relation to loanword phonology, although this word-specific property might be more or less related to the prestige of a source language in the semantic field (see 1.3). This is the motivation for the following specific question:

RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

In Chapters 3-5, we will investigate the relationship between the likelihood of choosing imported structure [ɾ] and words' association with Māori.

Given that we observe three types of sociolinguistic effects (i.e., situation-specific, speaker-specific, and word-specific factors) on the likelihood of adaptation vs. importation, they would suggest that rather than regarding loanword adaptation as being governed by strictly phonological (LaCharité & Paradis 2005) or phonetic properties (Peperkamp & Dupoux 2002), the study of loanword phonology would need to be embedded in more general theories of linguistic variation, particularly those that strive to account for the behaviour of sociolinguistic variables. Usage-based theories, such as Exemplar Theory (Pierrehumbert 2001; 2002), could allow us to account for socially driven variation, as discussed in 1.7. In relation to the overarching question [RQ1], the exploration of sociolinguistic effects on loanword phonology allows us to test the hypotheses about cognitive representations of imported structure and adapted structure.

1.6.2 Redundancy in adapted structure and imported structure

The goal of this sub-section is to discuss the research question [RQ1b] about the phonetic realization of a variant in loanword phonology in more detail. Section 1.4 reviewed previous literature about probabilistic reduction, which has demonstrated that acoustic redundancy in a signal is determined in accordance with lexical message predictability, that is, a lexical message tends to be realized with a reduced signal such as shorter duration and central formant frequency (i.e., lower phonetic redundancy), when the message is predictable from context, and vice versa. Message transmission in speech involves not only lexical messages but also social messages. To the best of our knowledge, less is known about the effect of social message predictability on the pronunciation of a linguistic variant. It is this research gap that motivates the second purpose of this thesis. Given that variation in loanword phonology is socially meaningful, variation in loanword phonology would provide an interesting test case to explore the social message predictability effect. The current thesis aims to increase our understanding of *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message* [RQ1b].

As stated in the preceding section, an /r/ sound in loanwords from te reo Māori to NZE

could be pronounced as an imported rhotic sound [ɾ] or an adapted rhotic sound [ɹ]. The current thesis will discuss the phonetic redundancy in these two variants in loanword pronunciation. By investigating the effect of sociolinguistic factors on the likelihood of adaptation vs. importation [RQ1a], it will be argued that this variation is socially meaningful, and that the two rhotic sounds carry different social messages. Namely, NZE speakers could express a social message by choosing one of the two variants. Hence, we could hypothesize that the predictability of a social message is represented by the predictability of choosing a variant. We will investigate to what extent the phonetic redundancy of the imported structure [ɾ] is influenced by the predictability of the imported structure [ɾ] as opposed to the adapted structure [ɹ] (i.e., the predictability of the social message carried by the imported structure), and to what extent the phonetic redundancy of the adapted structure [ɹ] is affected by the predictability of the adapted structure [ɹ] as opposed to the imported structure [ɾ] (i.e., the predictability of the social message carried by adapted structure). As will be discussed in 1.7.4, we will hypothesize that the phonetic redundancy of [ɾ] correlates with the duration of formant cessation, while the redundancy of [ɹ] correlates with the degree of lowering of F3. The reason is that the two acoustic properties (i.e., formant cessation and lower F3 values) are key cues for identifying each structure, that is, each social message. In sum, we will address the following specific research questions:

RQ6: "Is the duration of the imported structure affected by the predictability of the social message (i.e., the selection predictability of the imported structure)?"

RQ7: "Is the F3 of the adapted structure affected by the predictability of the social message (i.e., the selection predictability of the adapted structure)?"

These questions will be addressed in Chapters 6 and 7, respectively.

If we observe these social message predictability effects on the realizations of the variants in loanword phonology, we could conclude that the production of a linguistic variant is affected by the predictability of the social message. This would suggest that probabilistic reduction is not limited to lexical message predictability, as has been demonstrated in previous literature, but it is also caused by social message predictability. That is, this thesis will develop our understanding of the relationship between the realization of a message and predictability. As will be discussed in 1.7.4, a message-oriented approach, such as Message-Oriented Phonology (Hall et al. 2016; 2018), could enable us to capture probabilistic reduction in relation to social messages. By addressing the two specific research questions related to probabilistic reduction, we could test the hypotheses about how adapted structure and imported structure are processed in production of loanwords [RQ1].

1.7 Theoretical framework: exemplar space and articulatory bias

The purpose of this section is to offer a potential answer to the overarching research

question about the cognitive process of loanword phonology [RQ1]. We will construct a theoretical framework with hypotheses regarding how imported structure and adapted structure are stored in the mind of a borrower and processed in the production of a loanword. The hypotheses are based on previous literature about Exemplar Theory (Pierrehumbert 2001; 2002) and Message-Oriented Phonology (Hall et al. 2016; 2018). This theoretical model allows us to deduce predictions related to the specific research questions [RQ2-7] in the following section. We will be able to assess this framework by testing the predictions related to the concrete questions.

The theoretical framework models a production-perception loop, as schematized in Figure 1.3. As explained below, a production-perception loop is a speech pathway, in which detailed representations are updated on the basis of linguistic experience. Note that the numbers correspond with hypotheses and assumptions, which will be explained in more detail below. In this model, (0) a speaker represents both phonetically fine-detailed exemplars and categories, such as phonological categories, sociolinguistic categories, and lexical categories, in her cognitive system. When a speaker produces a linguistic signal, (1) the speaker first activates a category, and then (2) chooses several exemplars belonging to the category. The selected exemplars are averaged, and the averaged phonetic value becomes a production target. (3) The production target is subject to production biases, and the redundancy is modified in accordance with the message predictability. (4) Finally, the modified production target is produced as a signal with random production noise. (5) In perception, a speaker stores perceived tokens including self-produced tokens, as new exemplars.

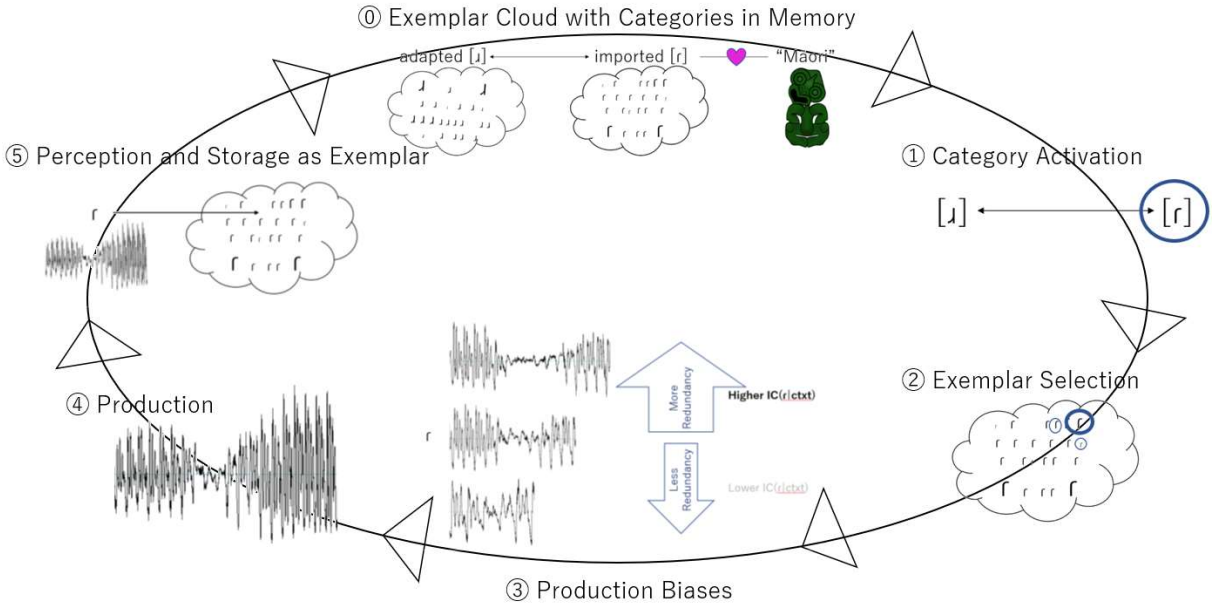


Figure 1.3 Production-perception loop

1.7.1 Exemplar cloud with categories in memory

Exemplar Theory assumes that linguistic knowledge is built up by representing in memory

tokens of previously encountered speech, and that they are stored with detailed phonetic information (Goldinger 1997; Johnson 1997; Pierrehumbert 2001; 2002; Foulkes & Docherty 2006; Wedel 2006; Ernestus & Baayen 2011; Hay & Foulkes 2016). These mentally stored tokens are called *exemplars*. Exemplars are classified on the basis of their similarity in exemplar space, and consequently they form a *phonological category* (e.g. allophone, phoneme, or feature), a *sociolinguistic category* (e.g. gender, social class, or age), and other linguistic categories such as lexical categories. Each category is associated with a large cloud of exemplars. Exemplars may be associated with more than one category (see Johnson 2006), and they can be associated with a variety of levels of categories including non-linguistic information as well as linguistic information simultaneously (Foulkes & Docherty 2006). For example, a coronal plosive produced by a girl living in Christchurch may be stored as an exemplar associated with phonological categories /t/ and [−continuant] as well as sociolinguistic categories "child," "female," and "kiwi." The categories may be cognitively linked with other phonological and sociolinguistic categories. For example, Fiasson (2015) argues that allophonic categories, namely a released variant [t] and a fricated variant [F], of a coronal plosive phoneme /t/ are cognitively linked, and thus shadowing a short medial fricated variant [F] has the effect of shortening a medial released variant [t] (see also Nielsen 2011). In this way, exemplars and categories are connected in a complex manner, and a large cloud of memories is formed in a cognitive system. On the basis of these exemplars and categories, it follows that the statistical properties of word-specific and speaker-specific (i.e., system-specific) variation could be retrieved. For example, the ratio of fricated variants given a word (e.g. *but͡ter* and *lat͡te*) could be retrieved from the number of exemplars with fricated variants and released variants associated with the lexical category, and the ratio of fricated variants given a speaker could be retrieved from the number of exemplars with fricated variants and released variants within the whole cognitive system of the speaker.[2]

In the case of loanword phonology in NZE, we specifically hypothesize that (0a) exemplars including imported structure [ɾ] and adapted structure [ɹ] are stored in the mind of a NZE speaker, and the phonological categories [ɾ] and [ɹ] are formed and represented in her

[2] As will be discussed in 1.7.6, the current study assumes that exemplar space is granularized (i.e., tokens that are acoustically different but perceptually identical are stored as a single exemplar with a particular perceptual-acoustic value), and thus the number of exemplars does not represent the exact number of tokens speakers encounter in speech. Despite this assumption, the number of granularized exemplars may correlate with the number of encountered tokens to some extent, because more encountered tokens should result in the higher number of granularized exemplars. Hence, we assume that speakers can approximate the number of encountered tokens on the basis of the number of granularized exemplars. In addition, speakers may also be able to approximate the number of encountered tokens on the basis of the strength of exemplars that is a function of the token frequency as will be discussed in 1.7.3. In the following figures, the size of a letter representing an exemplar indicates the strength of the exemplar.

mind, because both the structures are frequently used in NZE. Second, (0b) the categories of adapted structure and imported structure are cognitively linked with each other, as they are variants of /r/-sounds in Māori loanwords. Third, (0c) the imported structure [ɾ] is closely associated socially with the concept "Māori," because imported structure is identical to the structure used in the Māori language and society. Finally, we hypothesize that (0d) the probability of adapted structure and imported structure given a loanword is represented in the mind of a NZE speaker, because it can be retrieved from the number of exemplars with adapted structure and imported structure associated with the lexical category, and that (0e) the probability of adapted structure and imported structure given a speaker is also represented in the mind of each NZE speaker, because it can be retrieved from the number of exemplars with adapted structure and imported structure within the whole cognitive system of the speaker.

Figure 1.4 illustrates hypotheses (0a), (0b), and (0c). The letters inside the cloud represent individual exemplars, and the labels above the clouds represent categories formed in the cognitive system. Note that the size of letters represents the strength of exemplars, as will be discussed in the following two sections. The exemplars of adapted structure and imported structure are represented in the mind of a NZE speaker, and they form separate categories respectively (0a), but the two categories are cognitively linked (0b). The category of imported structure is strongly associated with the language-external concept "Māori" (0c). The strong association is represented by the heart drawing.

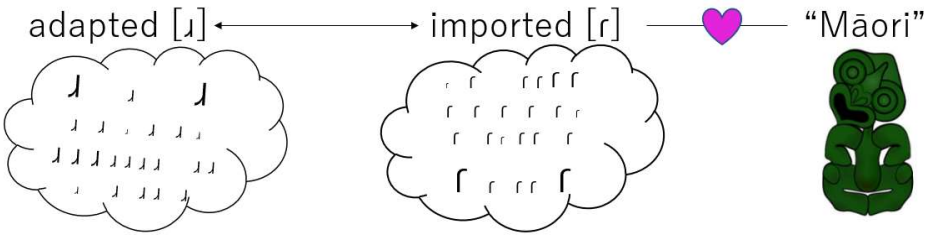


Figure 1.4 Category and exemplar association

Figure 1.5 illustrates the hypotheses (0d) and (0e). As with Figure 1.4, the letters inside the clouds represent individual exemplars, and the labels above and below the clouds represent phonological and lexical categories respectively. The three lexical categories[3] ("Timaru," "kumara," and "koru") are associated with fine-detailed exemplars, and thus adaptation probability and importation probability given each lexical category (i.e., loanword) could be

[3] The reason why *Timaru*, *koru*, and *kumara* are chosen as examples to illustrate the hypothetical exemplar space in Figure 1.5 is that each of these words is in a different category; words that are likely to be produced with adapted structure, those likely to be produced with imported structure, and those produced with one of the variants with the probability of about 50%. According to the results of Experiment 2 (see Chapter 4), the importation rate of *Timaru* is around 28%, that of *koru* is roughly 78%, and that of *kumara* is approximately 54%.

retrieved from the number of exemplars with adapted structure and imported structure that are associated with each lexical category (0d). Furthermore, exemplars with adapted structure and imported structure are associated with each phonological category and the phonological categories are cognitively linked with each other (0b), the result of which is that the probability of adapted structure and imported structure given a whole cognitive system (i.e. speaker) could also be retrieved from the total number of exemplars in the system (0e).

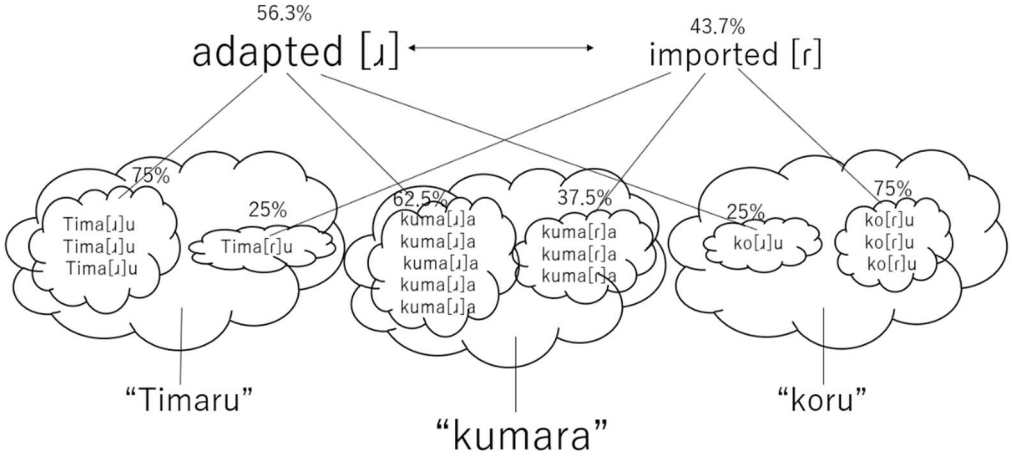


Figure 1.5 Predictability retrieved from exemplar space

1.7.2 Category activation

Pierrehumbert (2001: 144) notes: "we assume that the decision to produce a given category is realized through activation of that label." That is, speakers begin speech production by activating a category they want to produce. For example, when speakers want to produce the word "cat," they may first activate the lexical category CAT and phonological categories /k/, /æ/, and /t/ before production. The likelihood of activating a particular category is influenced by (a) the strength of the exemplars belonging to the category and (b) the activation of the relevant category. As will be reviewed in the next section, exemplars have higher strength or potential activation levels when they are stored frequently and/or recently. The current study assumes that the likelihood of activation of a particular category is potentially a function of the strength of the exemplars belonging to the category. That is, a category represented by a larger number of exemplars with higher strength is likely to be activated due to its potential dominance, all else being equal. It is also known that a particular category may be more likely to be activated due to the activation of other relevant categories. For example, Hay et al. (2006) demonstrate that the activation of a concept "Australia" raises the activation of Australian vocalic categories, and consequently vowels are more likely to be perceived as Australian vowels by female NZE speakers (see also Hay & Drager 2010; Hay & Foulkes 2016). The current study assumes that the activation of a social category may raise the activation of a relevant linguistic category, the result of which is that the linguistic category is more likely to be activated.

As for the activation of a social category, it may occur due to either an external factor or

an internal factor. First, a social category may be activated by speech situations such as a topic in speech or a presented cultural image, as will be reviewed in 3.2 and 4.2. For instance, Love & Walker (2012) demonstrate that speaking about American football activates a social concept "America," and consequently speakers become more likely to produce American English rhotic variants, which are supposed to be associated with the social concept "America." Second, speakers may activate a social category due to their social property. Drager et al. (2010: 31) note that "The degree of activation depends on the speaker's attitudes and social biases. Positive attitudes and biases toward a social group result in activation of phonetic representations indexed to the social group." In other words, speakers may potentially activate a social concept when they have more positive attitudes towards the social group, and consequently they are more likely to activate and produce linguistic forms associated with the social concept. In fact, this attitude-oriented selection of a linguistic variant is well-attested in literature on sociolinguistic variation. For example, McEntegart & Le Page (1982: 105) note "Each individual creates for himself patterns of linguistic behaviour so as to resemble those of the group or groups with which from time to time he wishes to be identified," and Bell (2014: Ch.11) notes "speakers intentionally stylize linguistic features in order to call up associations with particular groups or identities." We assume that these attitude-oriented stylizations are caused by the intentional activation of the relevant social category (see also Drager 2009: Ch.6 for attitude-oriented category activation).

In the case of loanword phonology in NZE, we crucially hypothesize that (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category. That is, the imported structure is more likely to be activated if it is used more frequently and/or recently, all else being equal. On the other hand, the adapted structure is more likely to be activated if it is used more frequently and/or recently, all else being equal. Furthermore, we hypothesize that (1b) the activation of imported structure is more likely to occur when the concept "Māori" is activated, as we hypothesized above that (0c) imported structure is closely associated with the social concept "Māori." Finally, as for the activation of the social category "Māori," we hypothesize that (1c) the social concept "Māori" may be activated by speech situations such as a topic in speech or a presented cultural image and (1d) speakers may potentially activate the social concept "Māori" when they have more positive attitudes towards Māori. The hypotheses of (1c) and (1d) will be discussed in more detail in Chapters 3 and 4.

Figure 1.6 illustrates the hypothesis (1a). As with Figure 1.4, the letters represent individual exemplars, and their size indicates the strength. The number and strength of exemplars with imported structure is higher than those with adapted structure, and thus the category of imported structure is more likely to be potentially activated. Figure 1.7 illustrates hypothesis (1b). The activation of the concept "Māori" may raise the activation of imported structure, as they are cognitively linked with each other.

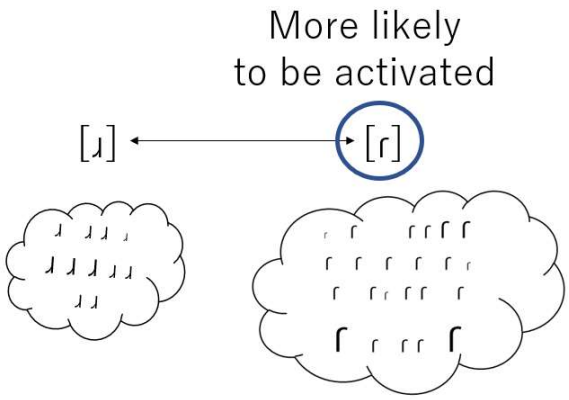


Figure 1.6 Potential likelihood of category activation

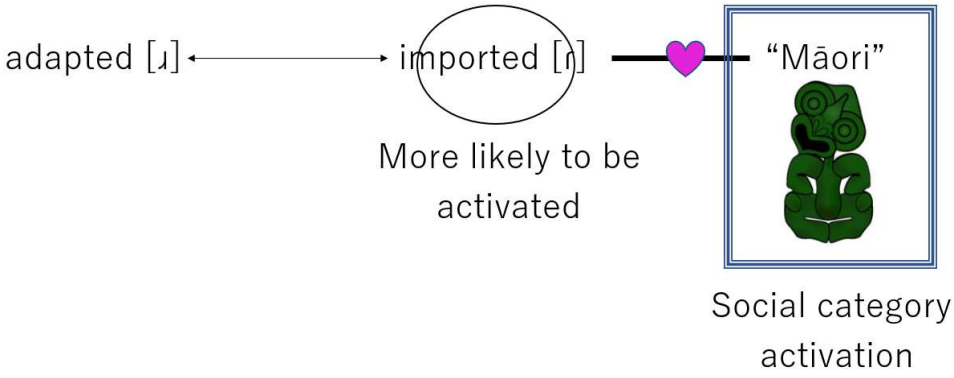


Figure 1.7 Activation of phonological category via activation of relevant concept

1.7.3 Exemplar selection

After category activation, a speaker chooses an exemplar belonging to the activated category for the production. Pierrehumbert (2001) assumes that "the likelihood that a particular exemplar will be selected is proportionate to its strength," and the strength of an exemplar is "a function of the number and recency of phonetic tokens at that location in the exemplar space." That is, exemplars encoding frequent and/or recent phonetic tokens have higher potential activation levels than exemplars encoding infrequent old phonetic tokens, and they are more likely to be selected in the production. In addition, Pierrehumbert (2001) assumes that exemplars surrounding the chosen exemplar also contribute to the production. In particular, a production target is formed by choosing a target exemplar and averaging the phonetic value of the exemplar with those of the surrounding exemplars. This mechanism is called "averaging." This mechanism is needed to account for a phenomenon known as entrenchment (see Pierrehumbert 2001; Wedel 2006), in which the variance for a category decreases with usage. For example, a L2 learner may produce a particular vowel with a variety of formant values in the early stage of the acquisition, but the learner may come to be able to produce the vowel with more fixed formant values. Figure 1.8 simulates how this averaging mechanism could make a particular category sharper. Imagine that a particular phonetic category is represented by 1,000 exemplars with particular acoustic values in the initial stage (red), and a production target is

formed by choosing 10 exemplars in a random way and averaging the acoustic values. After this category is produced 100 times (i.e., 100 production targets) and they are stored as new exemplars (see 1.7.6), the distribution becomes a little bit narrower (green). After 1,000 productions, the distribution becomes much narrower (blue). In this way, the exemplar-averaging mechanism allows us to encapsulate entrenchment. The R code to generate this figure is offered in Appendix A.

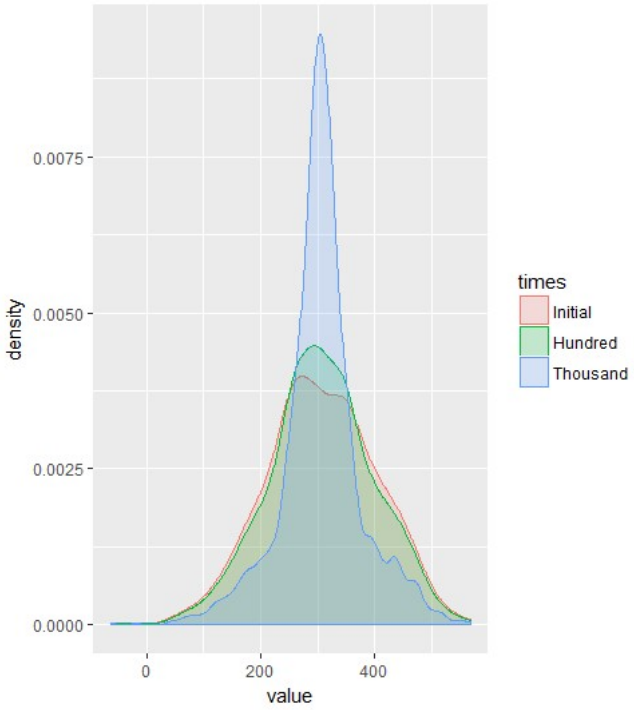


Figure 1.8 Hypothetical demonstration of entrenchment by exemplar-averaging

Following previous literature, we assume that (2a) an exemplar is chosen in accordance with the category selected during category activation (1), e.g., in the case of the NZE loanword phonology, an exemplar belonging to the phonological category [ɹ] is chosen when the category [ɹ] is activated, whereas an exemplar belonging to the phonological category [ɾ] is chosen when the category [ɾ] is activated, and that (2b) an exemplar with higher strength is more likely to be chosen for the production. Recall that the strength of an exemplar is a function of the frequency and recency of the storage. In addition, we assume that (2c) several adjacent exemplars are also chosen, and the average phonetic value of the selected exemplars becomes a production target.

Figure 1.9 illustrates assumptions (2a), (2b), and (2c). As with the above figures, the letters represent individual exemplars, and their size represents the strength. That is, larger letters represent exemplars encoding more frequent and/or recent phonetic tokens. After the activation of a phonological category of imported structure [ɾ], one exemplar belonging to this category is selected (2a). The selected exemplar, which is boldly circled, has relatively higher strength in comparison with the other exemplars, and thus it is likely to be chosen (2b). In addition, several exemplars surrounding the selected exemplar, which are circled, are also picked up, and

the average phonetic value of the chosen exemplars becomes a production target (2c). Note that this averaging mechanism will be elaborated further in Chapter 7.

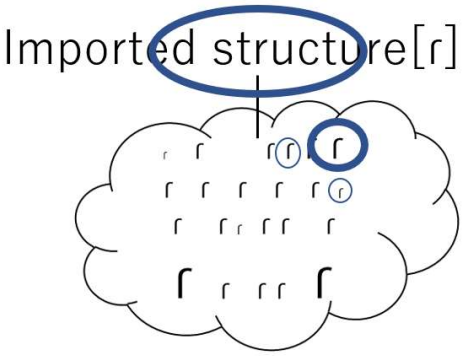


Figure 1.9 Exemplar selection

1.7.4 Production biases: trade-off between accuracy and resource cost

After a production target is determined through the exemplar selection process, it is subject to production biases (Pierrehumbert 2001). This adjustment process is external to the exemplar cloud, that is, it cannot be deduced from the assumption about the exemplar cloud itself, and needs to be assumed independently. The production target is modified by this process to satisfy articulatory, social, and other requirements, and the outcome is produced as a signal. We focus on production biases to reduce resource cost (i.e., improve efficiency in message transmission), because our interest lies in the predictability-oriented reduction of linguistic signals as in RQ1b. Note that there are a variety of production biases being assumed to account for sociolinguistic shifts and language change (see Pierrehumbert 2002; Todd 2019).

As was noted in 1.4, it has been demonstrated that more predictable messages are likely to be realized with reduced signals (see Hall et al. 2016; Jaeger & Buz 2017). In other words, speakers add more redundancy (phonetic substance) to linguistic signals carrying unpredictable messages, while they reduce redundancy in those carrying predictable messages. In order to account for this probabilistic reduction, the theoretical model in the current study employs the mechanism from Message-Oriented Phonology (MOP) (Hume 2016; Hall et al. 2016; 2018) of trading off accuracy and resource cost as communication-based biases that influence production.

MOP assumes that sound systems are shaped by the trade-off between accuracy and resource cost within message transmission. A *message transmission system* is defined as a system in which a transmitter encodes an intended message into a signal and sends it to a receiver who reconstructs the message from the signal (Shannon 1948; Pierce 1980). In a spoken language system, a *message* is a meaning-bearing unit (e.g. lexical meaning, social meaning, pragmatic meaning), a *signal* is a phonetic form with acoustic gradient features (e.g. intensity, formant values and durations), and a transmitter and a receiver are a speaker and a listener respectively. The message transmission is *accurate* and successful if the message encoded by the transmitter (i.e. intended message) is identical to that decoded by the receiver:

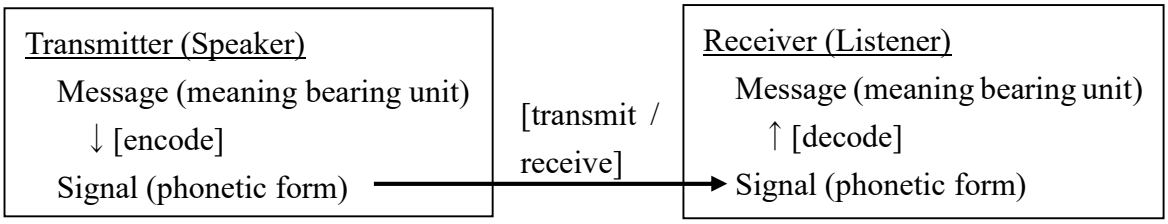


Figure 1.10 Message transmission in spoken language

The accuracy of message transmission is influenced by manipulating *redundancy* in a cue. A cue with greater redundancy "contains detail beyond that which is necessary for accurate message transmission under ideal conditions" (Hall et al. 2016). Generally speaking, higher redundancy in message transmission results in higher probability of successful message transmission. There are two sources of redundancy. First, *message predictability* refers to the predictability of the intended message given a context. For example, a word "ninja" is more likely to be heard in speech about Japan than in speech about New Zealand. That is, the lexical message of "ninja" has higher message predictability given the topic about Japan. This type of redundancy can be enhanced by adding more sentences or discourse markers in speech. Second, *signal specificity* refers to the degree to which a signal uniquely identifies the intended message. It is enhanced by adding phonetic cues (i.e., phonetic redundancy) to the signal associated with the intended message, because additional phonetic cues can differentiate the intended message further from its competitors. For instance, it is easier to single out an intended message "wheat" against other lexical competitors such as "weed" and "week," when the signal contains clear cues to the word-final voiceless coronal plosive /t/ (e.g., longer VOT and clearer formant transitions between vowels and consonants) like [wi:t^{h}], than when the signal lacks these acoustic cues like [wi:ʔ] or [wi:t̚]. These two types of redundancy determine the probability of accurate message transmission. Hall et al. (2016) note "Message predictability and signal specificity jointly influence accurate message transmission: the greater the predictability of a message and the more specific the signal is to the intended message, the less uncertainty there will be about the outcome being the intended message, all else being equal," and this relationship can be formulated in the following way:

(5) Successful message transmission as a function of two types of redundancy (message predictability and signal specificity)[4]

$$\text{Probability of accurate message transmission} = \text{message predictability} * \text{signal specificity}$$

[4] Hall et al. (2016) formulate this relationship in a more precise manner using Bayes Theorem. The interested reader should refer to their work.

Although increasing redundancy can facilitate accurate message transmission, it also incurs additional resource cost, which decreases the efficiency of the message transmission. The notion of *resource cost* refers to costs to the system due to added redundancy. As was seen above, additional sentences or explanations may need to be provided to increase message predictability, and additional articulatory effort may need to be made to increase signal specificity. These additional costs are examples of resource cost. Resource cost requires more effort to communicate and can make our communication slower (see Aylett & Turk 2004; 2006; Levy & Jaeger 2007), resulting in a more inefficient message transmission system. In sum, increasing redundancy increases the probability of more accurate message transmission but also of less efficient message transmission; decreasing redundancy results in more efficient message transmission but less accurate message transmission. In this way, biases for maximizing accuracy and minimizing resource cost usually conflict with each other. This trade-off between accuracy and resource cost in message transmission can be schematized as in Figure 1.11.

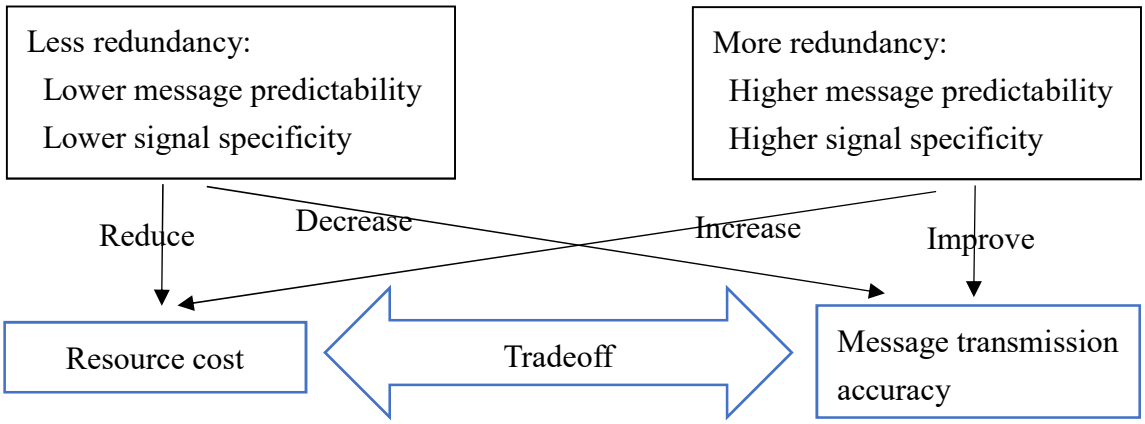


Figure 1.11 Trade-off between accuracy and resource cost

MOP hypothesizes that speakers use "the right sort of redundancy" to avoid "inefficient redundancy," and thereby augment "the likelihood of sufficiently accurate and cost-effective message transmission" (Hall et al. 2016). That is, this approach hypothesizes that effective communication involves balancing resource cost and message transmission accuracy, and this "effective trade-off" results in phonetic variability. Consequently, this theoretical framework predicts that redundancy in a message and a signal is determined by the probability of accurate message transmission, i.e., redundancy will be increased (thereby increasing the accuracy) when the probability of accurate message transmission is lower than sufficient, whereas redundancy will be decreased (thereby decreasing the resource cost) when the probability of accurate message transmission is higher than sufficient.

As our interest lies in reduction of a signal, let us consider when resource cost is invested and divested in a signal (i.e., signal specificity is enhanced and decreased). The answer derives from the formula in (5). Imagine that the probability of accuracy needs to be at least 8. When the uncertainty about the message is higher given the context and thus the message

predictability is a lower value (e.g., 2), the signal specificity needs to be higher (e.g., 4) to lead to sufficiently accurate message transmission, i.e., 8 = 2 * 4, resulting in more resource cost that is due to increasing signal specificity. When the uncertainty about the message is lower given the context and thus the message predictability is a higher value (e.g., 4), the signal specificity can be lower (e.g., 2), i.e., 8 = 4 * 2, resulting in less resource cost that is due to decreasing signal specificity. In the case of "wheat," the lexical message is predicted to be realized with more acoustic redundancy such as [wi:t^{h}] to differ further from other lexical competitors such as "weed" and "week" (i.e., improve the signal specificity), when the message is less predictable from context; the message is predicted to be realized with lower acoustic redundancy such as [wi:ʔ], to reduce resource cost, when the message is more predictable from context. In this way, MOP predicts that more redundancy is added in a signal when the intended message is less predictable, and vice versa, by postulating the effective trade-off between accuracy and resource cost within message transmission:

(6) Signal modification principle: effective trade-off between accuracy and resource cost (Hume 2016: 110)

a. Increase redundancy in a signal when the message carried by the signal is less predictable given the context (i.e. the message predictability is lower), thereby increasing the accuracy.

b. Decrease redundancy in a signal when the message carried by the signal is more predictable given the context (i.e. the message predictability is higher), thereby increasing the efficiency.

This signal modification principle based on the effective trade-off is employed as biases to enhance and reduce articulatory redundancy in the current study. That is, the current study assumes that the production target determined by exemplar selection is modified in accordance with this principle, i.e., redundancy is added to the production target when the message that it conveys is less predictable, and thereby the signal specificity is increased and the probability of accurate message transmission is enhanced. Conversely, redundancy is reduced from the production target when the message that it conveys is more predictable, and thereby the efficiency of message transmission is enhanced. This balancing mechanism is illustrated in Figure 1.12. The x-axis represents the predictability of the intended message, and the y-axis represents the standardized values of resource cost (i.e., values higher than 0 represent more redundancy than the average redundancy, and those lower than 0 represent lower redundancy that the mean redundancy).

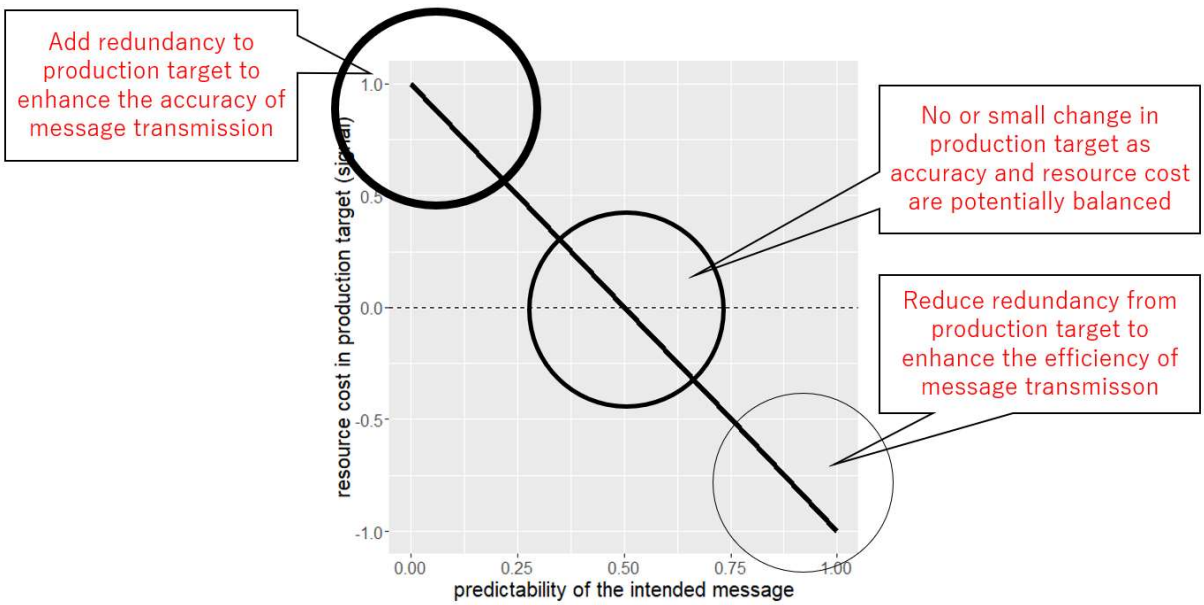


Figure 1.12 Effective trade-off determines redundancy in production target

In the case of NZE loanword phonology, by exploring the effects of sociolinguistic factors on the variation [RQ1a], we will argue for a hypothesis that (3a) adaptation vs. importation is sociolinguistically meaningful variation, and adapted structure and imported structure carry different social messages, i.e., adapted structure and imported structure are both social-message-bearing units. More specifically, we will hypothesize that adapted structure carries a social message dissociated from Māori (or a sort of neutral social message) while imported structure carries a social message associated with Māori. That is, speakers can convey one of the social messages by choosing one of the two variants of /r/-realizations in Māori loanwords, see 3.5.4. Following the signal modification principle in (6), we hypothesize that (3b) speakers are more likely to invest resource cost in a production target (i.e., enhance the signal specificity) when its social message is less predictable given the context, and vice versa. This hypothesis is illustrated by Figure 1.12. The current study also hypothesizes that (3c) the predictability of the social messages carried by imported structure and adapted structure is represented by the selection predictability of imported structure [ɾ] as opposed to adapted structure [ɹ] given a context (i.e., p(ɾ|ctxt)), and the selection predictability of adapted structure [ɹ] as opposed to imported structure [ɾ] given a context (i.e., p(r|ctxt)), respectively. The reason for this is that a social message is conveyed by choosing one of the two sociolinguistically meaningful variants (i.e., [ɾ] vs. [ɹ]). The context will be defined as a word or a speaker, because these two contexts should be retrievable from exemplar space as hypothesized in (0d) and (0e). The predictability will be transformed into information content in the statistical analyses by taking the negative log base 2 ($-\log_2$) of the predictability, because it is known that information content represents well the amount of uncertainty associated with choosing a message (Shannon 1948; Goldsmith 2002; Hume & Mailhot 2013). Finally, we hypothesize that the signal specificity of a social message could be increased by adding acoustic cues that one variant possesses but the other

variant lacks. This would further differentiate the chosen variant from the other variant. More specifically, we hypothesize that (3d) the signal specificity of imported structure [ɾ] could be improved by lengthening the closure duration or the formant cessation (i.e., we assume that the lack of formant structure is a key cue to [ɾ]). As for the adapted variant [ɹ], the signal specificity could be increased by lowering the F3 value (i.e., we assume that a key cue to identifying [ɹ] is low F3). This hypothesis is illustrated in Figure 1.13. The left-most token represents a typical tap sound [ɾ] and the right-most token represents a typical approximant [ɹ]. Note that the red lines indicate F3 transitions, and the absence of the line indicates lack of formant structure. The left-most token has clear formant cessation, and it differentiates a tap sound further from an approximant. The reason is that formant cessation is characteristic of a tap sound while formant structure occurs in an approximant. That is, speakers could increase the signal specificity of imported structure by lengthening the formant cessation, thereby conveying a social message associated with Māori more accurately. The right-most token has a clear F3 lowering, which differentiates an approximant further from a tap sound, because a tap sound does not have this acoustic property. A vowel-tap-vowel sequence [VɾV] has formant structure of the vowels in which F3 is not lowered, while a vowel-approximant-vowel sequence [VɹV] has formant structure of the approximant in which F3 is lowered in comparison to the vowels (Lindau 1985; Olive et al. 1993; Ladefoged 2006; Johnson 2011). That is, speakers could increase signal specificity of adapted structure by lowering F3 further, thereby conveying a social message dissociated from Māori more accurately. As for the central token, it has neither clear formant cessation nor clear F3 lowering. This token is ambiguous, and thus a speaker's intended social message may not be conveyed accurately.

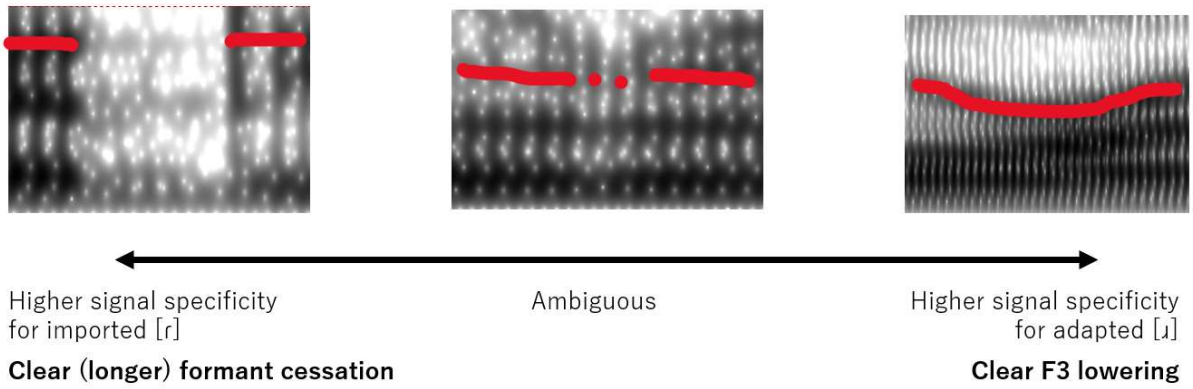


Figure 1.13 Signal specificity for imported structure and adapted structure

As illustrated in Figure 1.11, higher redundancy in a signal also incurs resource cost, and thereby decreases the efficiency of the message transmission. Hypothesis (3d) is plausible given this point of view. First, longer articulation of a sound makes communication slower in general (see Levy & Jaeger 2007), and longer formant cessation may require a speaker to articulate a tap sound more carefully. That is, taking more time to produce imported structure can increase

signal specificity and the accuracy of conveying the social message, while it requires more articulatory redundancy and decreases the efficiency of the message transmission. Next, F3-lowering requires additional articulatory effort such as tongue bunching (i.e., retroflexion), lip rounding, and pharyngeal constriction (Olive et al. 1993: 7.3; Johnson 2011: 140). In this way, the additional articulatory gesture(s) needed to lower the F3 of the adapted structure increases signal specificity and the accuracy of social message transmission, whereas it requires more articulatory redundancy and decreases the efficiency.

The following figures illustrate hypothesis (3d) about redundancy in imported structure and adapted structure respectively. Figure 1.14 illustrates the hypothesis that longer tap sounds [ɾ] have increased phonetic redundancy (and higher signal specificity of the social message associated with Māori), and Figure 1.15 illustrates the hypothesis that approximants with lower F3 values have more phonetic redundancy (and higher signal specificity of the social message dissociated from Māori).

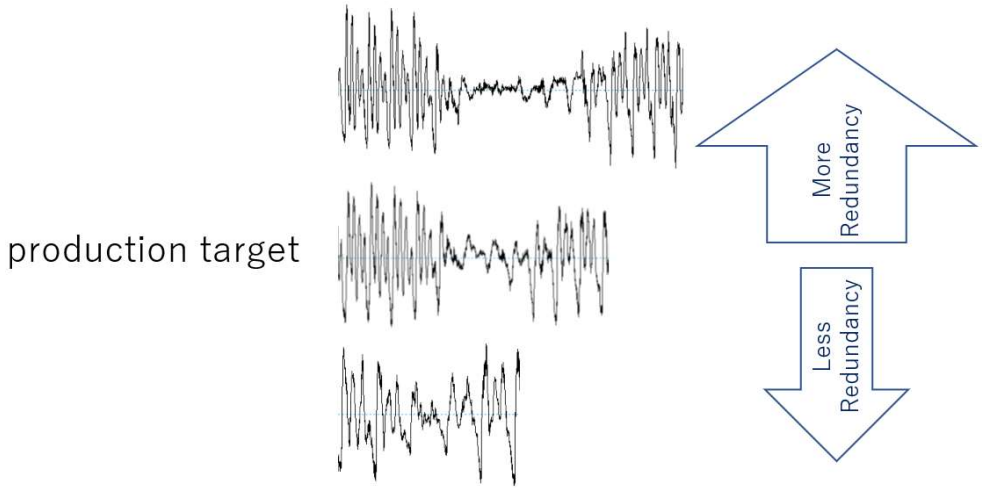


Figure 1.14 Redundancy in imported structure

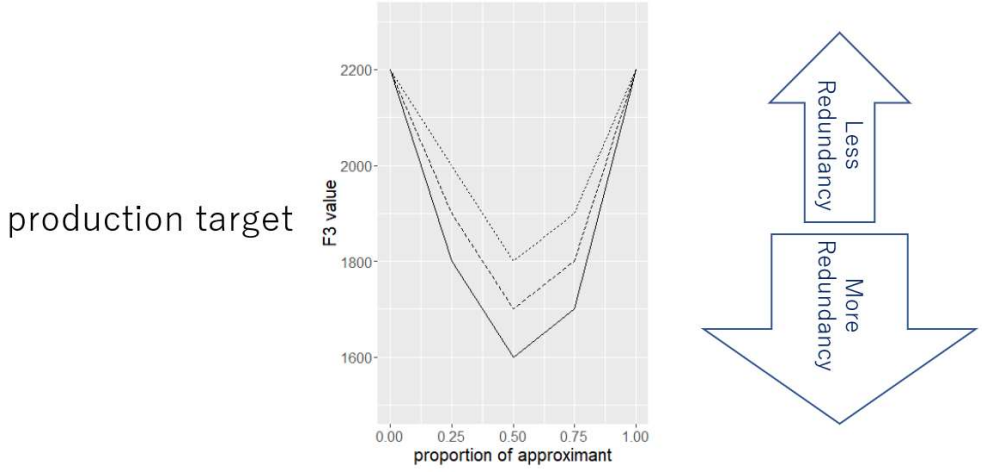


Figure 1.15 Redundancy in adapted structure

1.7.5 Production

After the production target undergoes the influence of the communication-based biases (i.e.

trade-off between accuracy and resource cost), through which it is modified depending on the message predictability, it is produced as a signal by speech organs. Pierrehumbert (2001) notes that the production target is not achieved exactly, but that random noise is added into the target. That is, the actual pronunciation is slightly different from the phonetic values determined so far. This noise is necessary to account for a Gaussian distribution of phonetic values of produced tokens (Pierrehumbert 2001), and the emergence of new variation (Wedel 2006).

Following the previous literature, we also assume that (4a) random noise is added to the production target determined through the last three processes (i.e., category activation, exemplar selection, and production biases), and the outcome is produced as a signal. This is illustrated in Figure 1.16.

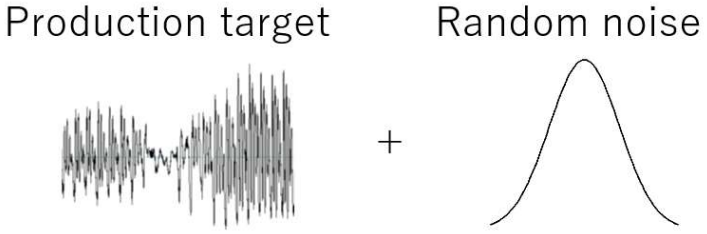


Figure 1.16 Production with a random noise

1.7.6 Perception and storage as an exemplar

As was reviewed above, Exemplar Theory assumes that essentially every token in speech is stored. The stored tokens include tokens that are produced by speakers themselves, as noted by Wedel (2006: 254): "Resulting production tokens are stored as new exemplars in their category of origin, completing the production/perception loop." This is unsurprising in that a speaker can perceive speech sounds produced by herself as well as other speakers. Needless to say, speakers cannot perceive speech sounds exactly, and thus random noise is added to the exemplar, that is, a new stored exemplar is slightly different from the actual pronunciation. In this way, production and perception occur repeatedly to develop a cloud of memories in a cognitive system, and this is the so-called "production-perception loop" (Pierrehumbert 2001).

Before concluding this section, it is worthwhile to incorporate two important assumptions, "decay" and "granularization," into our theoretical model. First, Exemplar Theory assumes that memories decay as they are no longer activated or used. Wedel (2006) proposes that exemplars die away when their activation levels fall below a particular threshold. Wedel (2006) demonstrates that this mechanism is needed to put a limit on excessive broadening of variation. In addition, this mechanism might be necessary, as it is counter-intuitive that a speaker remembers all speech contents that she has encountered throughout her life (Pierrehumbert 2001). Second, Exemplar Theory assumes that exemplar space is granularized due to perceptual limits of human beings. There are speech sounds that are acoustically different, but speakers perceive identically. For example, [p] with VOT of 70.000001 milliseconds and [p] with VOT

of 70.000002 milliseconds are acoustically different, but the difference could not be perceived by any human beings. These sounds are stored as a single exemplar with a particular perceptual-acoustic value, and consequently exemplar space is granularized. Namely, unperceived differences are removed from our memory, and only successfully-perceived differences are stored. As was discussed in 1.7.2 and 1.7.3, we assume that frequently and/or recently perceived exemplars have higher strength, whereas infrequently and/or remotely perceived exemplars have lower strength. This strength is specified for each granularized exemplar. Note that the perceptual processes in the production-perception loop model have been elaborated further by Todd et al. (2019), and interested readers should refer to their study.

Following the previous literature, the current theoretical model assumes that (5a) perceived tokens, including self-produced tokens, are stored as new exemplars with random perception noise, that (5b) memories decay as they are not activated and their strength falls below a particular threshold, and that (5c) exemplar space is granularized, that is, tokens that are acoustically different but perceptually identical are stored as a single exemplar that is specified with a particular perceptual-acoustic value.

Figure 1.16 illustrates assumptions (5a) and (5c). The left-hand character represents a speaker, and the right-hand one represents an addressee. The sound wave represents an acoustically realized form, which is stored as a new exemplar with random noise (5a). The discrete dots inside the speaker's brain represent granularized exemplars that were stored in past experience (5c), and the colours of the discrete dots represent whether each exemplar is associated with one of the two categories [ɹ] or [ɾ].

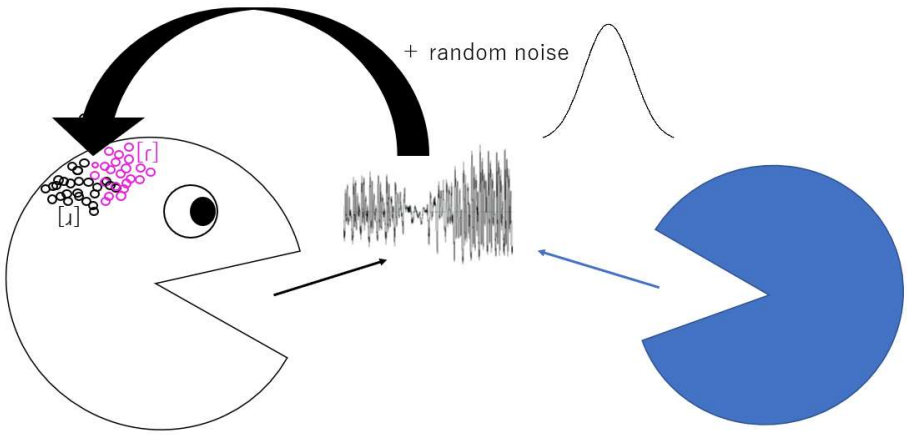


Figure 1.17 New exemplar and granularized exemplar space

1.8 Predictions

The aim of this section is to deduce predictions related to the six specific research questions [RQ2-7]. The preceding section offers a potential answer to the abstract research question [RQ1] by constructing a theoretical framework on the basis of Exemplar Theory and MOP. The framework consists of the hypotheses about how imported structure and adapted

structure are stored in the mind of a borrower and processed in the production of a loanword. In order to assess the validity of the hypotheses, we will test the predictions relevant to the six specific research questions, which could be deduced from our framework. In what follows, we will explain the predictions.

1.8.1 Selection of adaptation vs. importation

First, we will deduce predictions from our theoretical framework that are relevant to the research question [RQ1a]: *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors.* As was seen in 1.6.1, this concrete research question yields the four specific research questions [RQ2-5]. The predictions relevant to these questions can be deduced mainly from the hypotheses related to (0) exemplar clouds and (1) category activation. Note that these predictions will be discussed in more depth in Chapters 3-5.

RQ2: "Is the likelihood of adaptation vs. importation affected by topic in speech?"

It has been demonstrated that a topic in speech activates the relevant concept in sociolinguistic variation (Walker 2014), discussed in more detail in 3.2.2.1. In our case, it can be hypothesized that, (1c) when borrowers talk about something related to Māori in speech, the topic activates the concept "Māori." We crucially hypothesize that (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated, because (0c) the imported structure [ɾ] is socially associated closely with the concept "Māori." It is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these statements, we can deduce the following prediction:
Prediction 2: When a NZE speaker talks about something related to Māori in speech, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

RQ3: "Is the likelihood of adaptation vs. importation affected by cultural images?"

It was demonstrated that a visual expression activates the relevant concept in sociolinguistic variation (Hay & Drager 2010, see 4.2.2.1). In our case, we can hypothesize that, (1c) when borrowers see a cultural image related to Māori, the visual image activates the concept "Māori." It was crucially hypothesized that (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated, because (0c) the imported structure [ɾ] is socially associated closely with the concept "Māori." It is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these hypotheses and this assumption, the following prediction can be put forward:
Prediction 3: When a NZE speaker sees a cultural image related to Māori when speaking, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"

Imported structure is considered more likely to be used in the Māori language and community, because it is the structure identical to that used in te reo Māori, and the usage of the structure has been promoted by the Māori community. Hence, we could hypothesize that if speakers have stronger social associations with Māori, they may have more opportunities to store exemplars with imported structure, and exemplars with imported structure have higher strength, as discussed in detail in 3.2.2.2. We crucially hypothesized that (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category, and it is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these statements, the following prediction can be deduced:

Prediction 4a: If a NZE speaker has a stronger relationship with Māori (i.e., the source language and its culture), the speaker may be exposed to more imported structure and store more exemplars with imported structure, with the result that that the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

A speaker may activate a particular social concept when she has positive attitudes towards the social concept or the relevant social group (Drager et al. 2010, see 3.2.2.2). In the case of NZE loanword phonology, we could hypothesize that (1d) speakers may potentially activate the social concept "Māori" when they have more positive attitudes towards Māori. In addition, it is crucially hypothesized that (0c) the imported structure [ɾ] is socially associated closely with the concept "Māori," and that (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated. We assume that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these, the following prediction can be put forward:

Prediction 4b: If a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori," and consequently the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

Given that imported structure is used more often in the Māori community, imported structure may be heard more often in loanwords strongly associated with Māori in comparison with those weakly associated with Māori. Consequently, loanwords strongly associated with Māori may be more likely to be stored with imported structure in memory, and exemplars with imported structure have higher strength amongst exemplars associated with these lexical categories (see 3.2.2.3). It is crucially hypothesized that (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars

belonging to each category, and it is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these hypotheses, the following prediction can be offered:

Prediction 5: If a loanword is more strongly associated with Māori (i.e., the source language and its culture), the loanword may more often be stored with imported structure, the result of which is that the loanword is more likely to be produced with imported structure [ɾ] than adapted structure [ɹ].

1.8.2. Production of imported structure and adapted structure

Next, let our theoretical framework deduce predictions relating to the research question [RQ1b]: *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message.* This concrete research question leads to the two specific research questions, as discussed in 1.6.2. The predictions relevant to the two research questions will be deduced mainly from the hypotheses related to (0) exemplar clouds and (3) production biases. These predictions will be fully discussed in Chapters 6 and 7.

RQ6: "Is the duration of imported structure affected by the predictability of the social message (i.e., the selection predictability of imported structure)?"

By exploring sociolinguistic effects on the likelihood of choosing adapted structure vs. imported structure, we will argue for the hypothesis that (3a) imported structure carries a social message associated with the source language and its community. As was discussed in 1.7, we assume that (1) speakers begin speech production by activating a category they want to produce. In the case of loanword phonology in NZE, we assume that a speaker activates a particular lexical category in accordance with her intended lexical message, and then activates either adapted structure or imported structure to express her intended social message. Then, a production target is formed by (2a) choosing an exemplar belonging to the activated category and (2c) averaging the exemplar with the surrounding exemplars. During this process, a speaker could retrieve (0d) the probability of imported structure as opposed to adapted structure given a loanword (i.e., $p(ɾ|\text{loanword}_x)$) and (0e) the probability of imported structure as opposed to adapted structure given a speaker ($p(ɾ|\text{speaker}_x)$), based on the exemplar space. These two types of selection predictability are hypothesized (3c) to represent the predictability of the social message carried by imported structure, because the social message is expressed by choosing the imported structure as opposed to adapted structure. We crucially hypothesized that (3b) speakers are more likely to reduce redundancy in a production target when its social message is more predictable given the context, and vice versa (see signal modification principle in (2) and Figure 1.12). Finally, we hypothesize that (3d) the redundancy of imported structure correlates with its duration (i.e., speakers can improve the signal specificity by lengthening the formant cessation, see Figure 1.14). On the basis of these hypotheses and assumptions, the following prediction can be put forward:

Prediction 6: Imported structure with lower information content (i.e., a social message carried by imported structure is more predictable) given a loanword and given a speaker is more likely to be produced with shorter duration, all else being equal.

RQ7: "Is the F3 of adapted structure affected by the predictability of the social message (i.e., the selection predictability of adapted structure)?"

As with imported structure, by exploring sociolinguistic effects, we will argue for the hypothesis that (3a) adapted structure carries a social message dissociated from the source language and its community (or a sort of neutral social message). As was discussed above, in the case of loanword phonology in NZE, we assume that (1) a speaker activates a particular lexical category in accordance with her intended lexical message, and then activates either adapted structure or imported structure to express her intended social message. Then, a production target is formed by (2a) choosing an exemplar belonging to the activated category and (2c) averaging the exemplar with the adjacent exemplars. During this process, a speaker could retrieve (0d) the probability of adapted structure as opposed to imported structure given a loanword $p(\text{ɪ}|\text{loanword}_x)$ and (0e) the probability of adapted structure as opposed to imported structure given a speaker $p(\text{ɪ}|\text{speaker}_x)$, based on the exemplar space. It is hypothesized that (3c) these two types of selection predictability represent the predictability of the social message carried by adapted structure, because the social message is expressed by choosing adapted structure as opposed to imported structure. We crucially hypothesized that (3b) speakers are more likely to reduce redundancy in a production target when its social message is more predictable given the context, and vice versa (see signal modification principle in (2) and Figure 1.12). Finally, we hypothesize that (3d) the redundancy of adapted structure correlates with the degree of lowering of F3 (i.e., speakers can improve the signal specificity by lowering F3, see Figure 1.15). The following prediction can be deduced on the basis of these hypotheses and assumptions:

Prediction 7: Adapted structure with lower information content (i.e., a social message carried by adapted structure is more predictable) given a loanword and given a speaker is more likely to be pronounced with higher F3, all else being equal.

1.9 Overview of thesis

Finally, this section overviews this thesis. This chapter has reviewed previous literature relevant to the current thesis, and presented research questions. The overarching research question in this thesis is [RQ1] *how imported structure and adapted structure are stored in the mind of a borrower and processed in the production of a loanword*. This abstract research question is investigated by addressing two concrete research questions about the likelihood of choosing a variant in loanword phonology [RQ1a] and redundancy in the variant [RQ1b], leading to six specific research questions [RQ2-7]. After the clarification of the research questions, a theoretical framework was developed based on Exemplar Theory and MOP. This

theoretical framework offers a potential answer to the overarching research question [RQ1], that is, it is constructed from a series of hypotheses regarding the mental representation of imported structure and adapted structure and those regarding the processing of these two structures. Finally, on the basis of the theoretical framework, we deduced predictions relevant to the specific research questions [RQ2-7]. We can assess our theoretical framework by testing the specific predictions in the following chapters.

Chapter 2 will explain the questionnaires employed in the current study. As stated above, the current study explores how the pronunciation of loanwords is affected by speaker-specific and loanword-specific properties. In order to address these research questions, the participants in this study filled in questionnaires. The design and results will be provided in the chapter.

Chapters 3-5 are related to the concrete research question [RQ1a]: *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors*. Addressing this question allows us to test the hypotheses about how imported structure and adapted structure are represented in the mind of a borrower. Chapter 3 will discuss the topic effect [RQ2] using a passage-reading task, and Chapter 4 will explore the cultural image effect [RQ3] using a word-list reading task. Chapter 5 will report a follow-up experiment to re-explore the two situation-specific sociolinguistic factors. In these three chapters, we will additionally explore speaker-specific sociolinguistic effects [RQ4] and word-specific sociolinguistic effects [RQ5]. The results will suggest that variation in loanword phonology is socially meaningful, and imported structure and adapted structure carry different social messages respectively.

On the basis of the argument for social messages in loanword phonology, Chapters 6-7 address the other research questions [RQ1b]: *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message*. This question allows us to inform the understanding of how imported structure and adapted structure are processed in production. Chapter 6 will explore redundancy in imported structure [RQ6], and Chapter 7 will discuss redundancy in adapted structure [RQ7]. These two chapters employ the same dataset discussed in Chapters 3-5. They provide partial evidence that redundancy in a signal is affected by social message predictability.

Chapter 8 will summarize the findings throughout the current study. We will assess the theoretical framework constructed in the current chapter by discussing the results of the experiments reported in Chapters 3-7, and point out further implications and remaining issues. At the end, a conclusion will be offered.

Chapter 2 Questionnaires: Speakers' and words' association with source language and its culture

2.1 Introduction

The aim of this chapter is to explain the questionnaires employed in the current study. As was clarified in the previous chapter, one aim of this thesis is to explore the effects of speaker-specific properties and word-specific properties on the pronunciation of loanwords. In order to test these properties, participants in this research answered questionnaires after they took part in the experiments reported in the following chapters. The set of these experiments was approved by Kaiārahi Māori Research and Human Ethics Committee at the University of Canterbury. As will be explained in the following three chapters, 32 participants (P1-P32) took part in both Experiments 1 and 2, and other 64 participants (P33-P96) participated in Experiment 3. In what follows, all of the 96 participants are analysed and discussed alongside each other, as a larger number of observations may improve the validity of the statistical analysis.

The questionnaires consist of two main parts. One part is about speaker-specific properties, and the other part is about word-specific properties. In this chapter, we will explain both parts of the questionnaires and clarify how they are statistically analysed.

2.2 Speaker-specific properties

The participants in this research answered questionnaires about their social properties first. These questions consist of two parts: general properties (2.2.1) and speakers' association with Māori (2.2.2). The latter part of questionnaires is statistically analysed using Principal Component Analysis (PCA), and this analysis will be explained in 2.2.3.

2.2.1 General information

First, participants answered general questions about themselves. They filled in questionnaires about their gender, place of birth, living place(s), languages they can speak, and social identity. The main purpose of these questions is to make sure that participants satisfy the criteria for these experiments. By specifying in the advertisements (see Appendix B), it was ensured that all the participants are non-bilingual Pākehā New Zealand English speakers aged between 18-35. Recall that Pākehā usually refers to New Zealanders of European descent, as noted in 1.5.1. The reason why only non-bilingual speakers were examined is that the fluent knowledge of Māori may result in code-switching rather than lexical borrowing. In fact, the distinction between code-switching and lexical borrowing is still controversial when a lone foreign word is pronounced (see Boztepe 2005). For example, Poplack & Dion (2012) argue that "lone other-language items" are usually borrowings and "multiword fragments" are code-

switches, whereas Myers-Scotton (1992) claims that the distinction is gradient. It can be assumed more or less safely in the present study that speakers borrow Māori loanwords rather than code-switch as long as they are not fluent bilingual speakers, since code-switching is based on bilingualism. The reason why only Pākehā speakers were examined is that there is a different sociolinguistic variety associated with Pākehā speakers and Māori speakers (King 1993; Holmes 1996; Szakay 2007 among others), and Māori speakers may be exposed to te reo Māori in a different way from Pākehā speakers. By focusing on Pākehā speakers, we can control the effect of these sociolinguistic differences. The age requirement of 18-35 allows us to control the effect of a diachronic change. In what follows, we will outline the answers of the questionnaires in this section.

At the beginning of this section, the participants answered how old they are. All the participants fall into the range of 18-35, as required in the advertisements.

As for gender, there are more female speakers in the experiments reported throughout this thesis. 26 of 32 participants in Experiments 1 and 2 (81%) and 40 of 64 participants in Experiment 3 (62.5%) are female speakers. We will not explore the effect of gender in most parts of the current study, because the ratio is not well-balanced and there is no previous literature that argues that gender is an important predictor of the likelihood of adaptation vs. importation and the duration of a segment. The implications for the format structure of [ɪ], which is well-known to be affected by biological differences between males and females, will be discussed in Chapter 7.

As for a place of birth and living place(s), all the participants have spent most of their time in New Zealand. As will be discussed in Chapter 3, we will divide the participants into North Islanders and South Islanders in accordance with which island they have spent most time in. 21 of 32 participants (65%) in Experiments 1 and 2 are South Islanders, and 38 of 64 participants (59%) in Experiment 3 are South Islanders. Although the ratio is not well-balanced, this variable will be examined because it is likely to affect the pronunciation of Māori loanwords, as will be discussed in the next three chapters.

No participants reported that they are fluent in any other languages, as the advertisements specified that participants must not be fluent bilinguals. This allows us to observe borrowing rather than code-switching.

At the end of this section, the participants were asked whether they identify as Māori. 91 participants did not identify themselves as Māori, while 5 participants identified themselves as both Pākehā and Māori. These five participants reported that their distant relatives such as great grandparents were Māori. It turns out through a statistical analysis that these five participants have a slightly stronger association with Māori in comparison to the other speakers, as will be stated in 2.2.3. Note that these participants identified themselves primarily as Pākehā, and the percentage of Māori people amongst their family and friends is still quite low. According to their answers to questionnaires in Section C (see 2.2.2.3), the percentage ranges around 20% or lower.

2.2.2 Speakers' association with source language and its culture

As stated above, one of our predictions is that speakers who strongly associated with Māori would be more likely to produce imported structure. In order to measure how strongly a participant is associated with Māori, each participant was asked to fill in questionnaires, see Appendix C. The questionnaires are about their relationship with Māori, their attitudes towards Māori, and their individual and neighbourhood proficiency of te reo Māori. These various types of questions allow us to examine wider aspects of speakers' properties when compared to previous literature. In what follows, each section (Sections A-D) will be explained.

2.2.2.1 Relationship with Māori culture and language

The questionnaires in Section A are about relationship with Māori culture and language. The participants answered how often they participate in activities involving the use of the Māori language (e.g., greeting in te reo Māori and watching Māori language TV programs) and cultural activities (e.g., attending Māori ceremonies, going to a marae, and visiting Māori art exhibits).

The questionnaires employed in this section are adapted from national surveys conducted by Te Puni Kōkiri (2009) and Te Manatū Taonga (2009). These national surveys collect data about New Zealanders' Māori activities. Although the national surveys use Likert scales, a linear scale was employed in this study (see Redinger 2010 and Dollinger 2015: 251). The main reason for using a linear scale is that numeric variables are easy to handle in statistical analyses (see Llamas & Watt (2014) and Wang (2017) for disadvantages of using the Likert scale). The participants were asked to mark at anywhere on a horizontal line to show their answers. This technique is adapted from Redinger (2010). This section consists of the following 8 questions (Aa-Ah):

(1) Questionnaires on relationship with Māori culture and language

A. How often do you do the following? Please mark anywhere along the horizontal line.

Very Seldom ——————————————————— Very Often

a. Greet in Māori
b. Watch Māori language TV programs
c. Access websites that contain Māori language resources
d. Attend ceremonies or events with Māori welcomes and speeches
e. Visit Māori art, culture or historical exhibits
f. Go to Kapa haka or Māori culture group concerts
g. Go to a marae
h. Access websites about Māori culture

The line is 100mm long. The distance of the marked point from the left edge is regarded as a rated value, that is, the point ranges between 0-100. It was measured using a ruler.

The answers to the questionnaires in this section tend to be at a low value, and the range is relatively wide. This suggests that the strength of relationship with Māori culture and language varies depending on the participants, but they usually have a weak relationship. The distribution of the answers to the questionnaire Ah is a typical example. This is illustrated in Figure 2.1. The answers are widely distributed at the lower range. The mean is 19 points, the median is 9 points, and the standard deviation is 23 points.

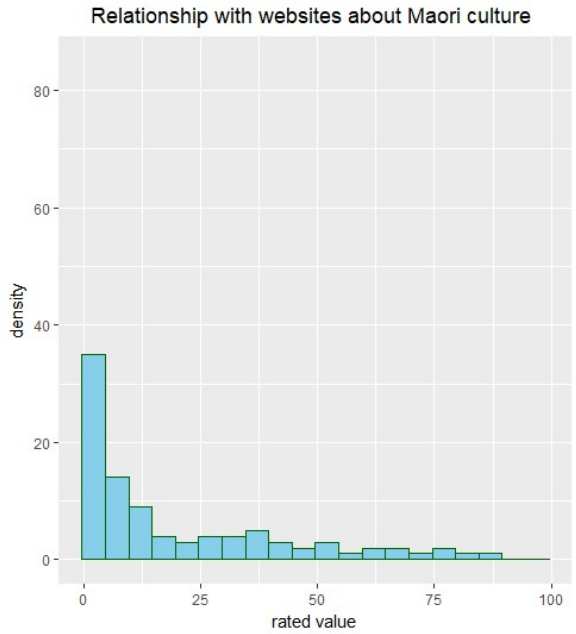


Figure 2.1 Histogram of answers to questionnaire (Ah)

2.2.2.2 Attitudes towards Māori culture and language

Next, the participants indicated their attitudes towards Māori by answering questionnaires in Section B. For example, they were asked about their attitudes towards greetings in te reo Māori, and their feelings towards more funding for Māori activities.

As with 2.2.2.1, the questionnaires employed in this section are adapted from those used in Te Puni Kōkiri (2009) and Te Manatū Taonga (2009). Some sections of these surveys focus on attitudes towards the Māori language and culture. For the same reason as 2.2.2.1, a linear scale was employed instead of a Likert scale, and the participants were asked to mark some point on a horizontal line. The measurement of the marked point is undertaken as in Section A. This section consists of the following 8 questions (Ba-Bh):

(2) Questionnaires on attitudes towards Māori culture and language

B. How strongly do you agree to the following questions? Please mark anywhere along the horizontal line.

Strongly Disagree ——————————————————— Strongly Agree

a. Well spoken Māori is beautiful to listen to.
b. It is OK for people to greet others in Māori.
c. It is a good thing that Māori people speak Māori in public places, such as in the street or supermarket.
d. I have a lot of respect for people who can speak Māori fluently.
e. Some Māori language education should be compulsory in school for all children.
f. Māori cultures and activities are an important part of NZ's national identity.
g. It is important to learn about Māori culture.
h. Māori cultural activities should receive some funding from Government.

The answers to the questionnaires in this section tend to be widely spread across higher values. This suggests that attitudes towards Māori culture and language differ depending on the participants, but they usually have positive attitudes. A typical example is the distribution of the answers to the questionnaire Bg. This is illustrated in Figure 2.2. The mean is 84 points, the median is 92 points, and the standard deviation is 17 points.

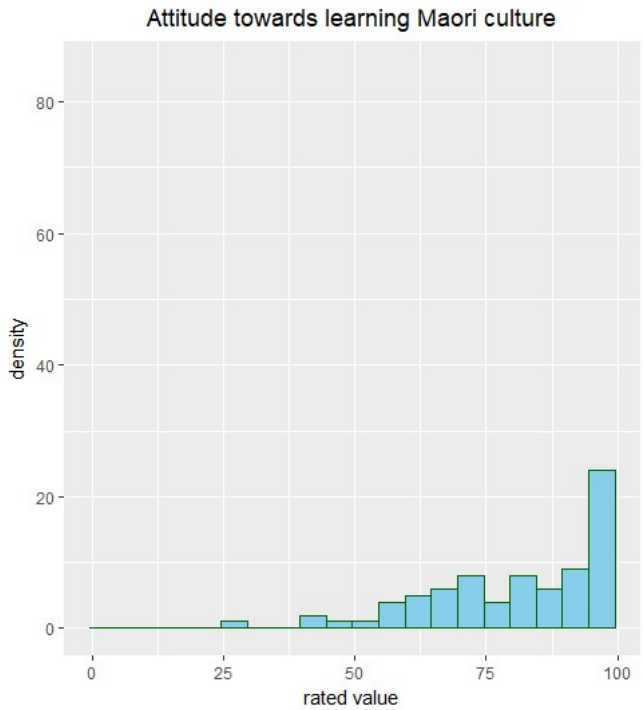


Figure 2.2 Histogram of answers to questionnaire (Bg)

2.2.2.3 Relationship with Māori people and neighbourhood proficiency

Next, the participants filled in questionnaires about their relationship with Māori people

and speakers. They answered how many Māori people and speakers they are familiar with. Instead of the raw number, they answered by noting the ratio of those people in their daily communities in the following questionnaires. This section consists of the following 10 questions (Ca-Cj):

(3) Questionnaires on relationship with Māori people and speakers

C. What is the percentage of the population of the following people surrounding you?

a. Māori relatives. (%)
b. Māori friends in daily life. (%)
c. Māori friends in online SNS. (%)
d. Māori classmates. (%)
e. Māori neighbours or flatmates. (%)
f. Relatives who can speak Māori. (%)
g. Friends in daily life who can speak Māori. (%)
h. Friends in SNS who can speak Māori. (%)
i. Classmates who can speak Māori. (%)
j. Neighbours who can speak Māori. (%)

The answers to the questionnaires in this section tend to be at a very low rate, and the range is narrower than the above two sections. That is, most participants equally have a very weak relationship with Māori people and speakers. The distribution of the answers to the questionnaire Cb is a typical example. This is illustrated in Figure 2.3. The mean is 8.2%, the median is 5% and the standard deviation is 9.38%.

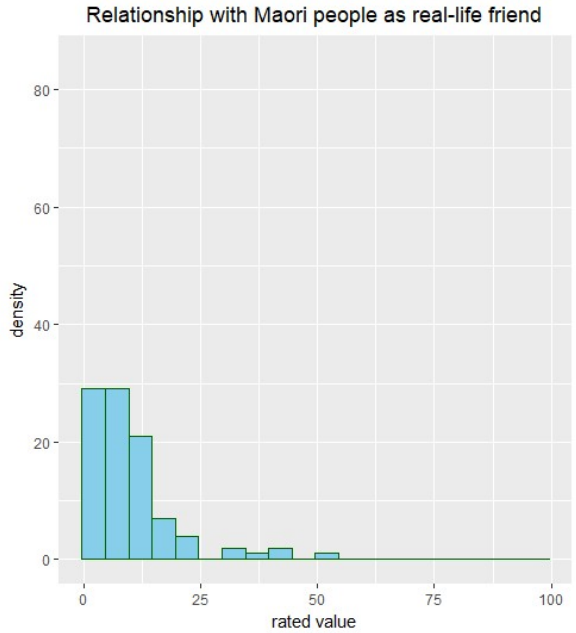


Figure 2.3 Histogram of answers to questionnaire (Cb)

2.2.2.4 Individual proficiency

Finally, the participants answered questionnaires about their fluency of te reo Māori. The following question is adapted from Te Puni Kōkiri (2009) and Te Manatū Taonga (2009):

(4) Questionnaires for individual proficiency of Māori

D. How well are you able to speak Māori in everyday conversation? Please select one of the following five choices.

1 Very well (I can talk about almost anything in Māori)
2 Well (I can talk about many things in Māori)
3 Fairly well (I can talk about some things in Māori)
4 Not very well (I can only talk about simple/basic things in Māori)
5 No more than a few words or phrases

As was noted above, it was made sure by specifying in the advertisements (Appendix B) that no participants were fluent bilingual speakers of te reo Māori. This allows us to examine borrowing rather than code-switching. Figure 2.4 shows the results. 64 participants (67%) marked "5 no more than a few words or phrases," 25 participants (26%) marked "4 not very well," and 7 participants (7%) marked "3 fairly well." No participant marked "2 well" or "1 very well:"

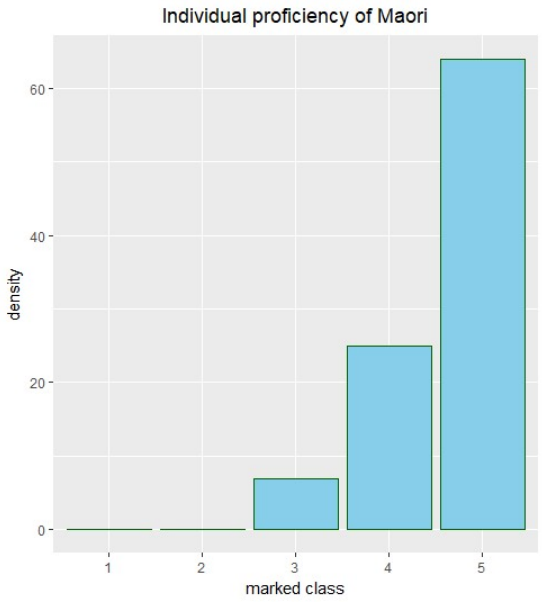


Figure 2.4 Bar-chart of answers to questionnaire (D)

2.2.3 Statistical analyses: principal component analysis

The 27 variables in the questionnaire (Sections A-D) were unified into three factors by performing a principal component analysis (PCA) on the result of the questionnaires. PCA is a dimension reduction method that allows us to create a small number of variables that index a

large set of variables that correlate highly. PCA was performed on all participants in the three experiments reported in this thesis, that is, 96 participants (32 participants in Experiment 1 and 2 and 64 participants in Experiment 3), because a larger number of observations improve the validity of the statistical analysis.

In what follows, we explain how PCA was performed. The answers for each questionnaire have different ranges of values, hence were first standardized prior to performing PCA. Following Field et al. (2012: Ch.17), a correlation matrix was first produced from the data of the questionnaires using the *cor()* function (R Core Team 2016). Bartlett's test and KMO test were run on the correlation matrix to confirm the assumptions (χ^2 (351) = 1343.229, p<.001, overall KMO = 0.75). It was made sure that all KMO values were well above the acceptance limit of .5. These values suggest that correlations between items are sufficiently large for PCA. The result of Bartlett's test tells us that the correlation matrix is significantly different from an identity matrix (i.e. there are some relationships between the variables), and that of KMO test suggests that the patterns in the correlation matrix are relatively compact and it is appropriate to perform PCA. Then, we created a principal component model with the same number of factors as there are in the questionnaire (i.e., 27 factors) using the *principal()* function (Revelle 2017). Based on this initial model, the point of inflection was determined by a parallel analysis executing the *fa.parallel()* function (Revelle 2017). Figure 2.5 is its output Scree plot, which shows factor loadings on the y-axis and the number of factors on the x-axis. Fields et al. (2012: 762) noted that "the cut-off point for selecting factors should be at the point of inflection of this curve. The point of inflection is where the slope of the line changes dramatically." This point of inflection is indicated by the red line in the following scree plot, which suggests that three factors should be retained (Revelle 2017: 145). The model with the three factors can account for 50% of the total variance:

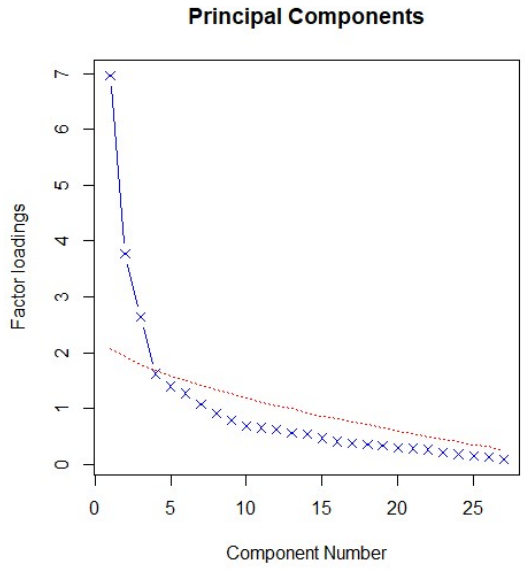


Figure 2.5 Scree plot from PCA of all participants

It is determined what each factor means by using the *print.psych()* function (Revelle 2017), which shows us which variable highly loads each factor. The variables highly loading the three factors are shown in Table 2.1 (only loading more than 0.3 is shown). The value of factor loading indicates how much each question contributes to each principal component:

ID	Abbreviation for questionnaires	PC1	PC2	PC3
Bf	Attitude towards attending Māori culture and activity	0.92		
Bc	Attitude towards speaking Māori in public	0.89		
Bg	Attitude towards learning Māori culture	0.84		
Bd	Attitude towards a fluent Māori speaker	0.83		
Bh	Attitude towards funding Māori cultural activity	0.75		
Be	Attitude towards Māori language education	0.73		
Ba	Attitude towards the ability to speak te reo Māori	0.62		
Bb	Attitude towards Māori greeting	0.59		
Ac	Relationship with websites using te reo Māori		0.83	
Ad	Relationship with Māori ceremonies or events		0.81	
Af	Relationship with Māori cultural group		0.74	
Ag	Relationship with marae		0.72	
Ah	Relationship with websites about Māori culture		0.72	
Ae	Relationship with Māori art		0.66	
D	Individual proficiency of te reo Māori		−0.54	
Aa	Relationship with Māori greeting		0.54	
Ab	Relationship with Māori language TV program		0.54	
Ca	Relationship with Māori people as relative		0.35	
Cc	Relationship with Māori people as online friend			0.74
Cg	Neighbourhood proficiency of real-life friend			0.68
Cj	Neighbourhood proficiency of neighbour			0.66
Ch	Neighbourhood proficiency of online friend			0.66
Ce	Relationship with Māori people as neighbour			0.65
Cb	Relationship with Māori people as real-life friend			0.54
Cd	Relationship with Māori people as classmate			0.54
Ci	Neighbourhood proficiency of classmate			0.43
Cf	Neighbourhood proficiency of relative			

Table 2.1 Three factors revealed by PCA and factor loadings (only loading more than 0.3 is shown)

The questions contributing to a principal component can be used to explain what each principal component means. As is clear, *PC1* basically includes questions about attitudes towards Māori

culture and language (questions in Section B); *PC2* essentially includes those about relationship with Māori culture and language (questions in Section A) and individual proficiency in te reo Māori (question in Section D); *PC3* includes those about relationship with Māori people and speakers (questions in Section C). Hence, these three factors can be interpreted in the following way:

(5) Meanings of three factors as a result of PCA
PC1: attitude towards Māori culture and language
PC2: relationship with Māori culture and language, and individual proficiency in Māori
PC3: relationship with Māori people, and neighbourhood proficiency in Māori

In the following chapters, *PC1* is referred to as *PC-attitude*, *PC2* is *PC-culture*, and *PC3* is *PC-people*.

In this way, the 27 questionnaires in Sections A-D were reduced to three principal components. By specifying the number of principal components and adding the *score=TRUE* to *principal ()*, the three principal components were assigned to each participant as in Table 2.2:

Participant	PC1	PC2	PC3
P1	0.96	−1.05	0.53
P2	−1.85	−0.01	−0.66
P3	0.94	1.33	−0.75
P4	0.16	0.87	0.68
P5	0.51	1.42	0.81
…	…	…	…
P96	0.73	0.13	−1.05

Table 2.2 Three factor scores revealed by PCA

These three principal components will be explored in the statistical analyses in the following chapters. As stated above, five participants identified themselves as Māori secondarily, because their distant relatives are Māori. This is why we explored their values of the three principal components. It was found that these five participants have a slightly stronger association with Māori in general.

Finally, the relationship between these three principal components and two sociolinguistic variables (*gender* and *speakerPlace*) was explored by performing Pearson correlation analyses and fitting linear regression analyses. Two correlations were found. First, it was found that speakers with higher *PC1* (i.e., *PC-attitude*) tend to have higher *PC2* (i.e., *PC-culture*). According to Pearson correlation analyses, the correlation is positive and weak (r=0.28). This suggests that positive attitudes towards Māori and a strong relationship with Māori culture may

influence each other. As will be seen in the following chapters, *PC1* and *PC2* will be fitted in a regression model together, but they do not cause multicollinearity problems due to their weak correlation. Next, it was found that North Islanders have higher PC2 (i.e., *PC-culture*) than South Islanders ($p<0.001$). This is unsurprising, because there are more Māori people living in the North Island and North Islanders may have more opportunities to participate in Māori activities. As will be seen in the following chapters, these two variables are not so strongly correlated as to cause multicollinearity. There is no statistically significant relationship between other variables.

2.3 Word-specific properties

After filling in the questionnaires about speaker-specific properties, the participants rated two types of word-specific properties (see Appendix C). As stated above, one of our predictions is that words strongly associated with Māori should be more likely to be produced with imported structure. In order to measure how strongly a loanword is associated with Māori, the participants rated loanwords employed in the experiments reported in the following chapters. The questionnaires about words' association with Māori will be explained in 2.3.2.

Although word frequency is not the variable of interest, it is known to affect the likelihood of adaptation vs. importation (Poplack & Sankoff (1984) and Friesner (2008; 2009)). Hence, this variable will be examined as a control variable. There is not a large number of tokens of Māori loanwords in any corpora, and thus it is difficult to measure their objective word frequency. Hence, subjective word frequency is employed in this study. The participants were asked to rate the subjective word frequency of each target loanword. The questionnaires about word frequency will be explained in 2.3.1.

The subjectively rated values of these two word-specific properties were standardized by individual speakers. The method will be provided in 2.3.3.

2.3.1 Word frequency

The first section of questionnaires about word-specific properties is about word frequency. The participants were asked to rate the subjective word frequency of target loanwords by answering the following question using a linear scale. The target loanwords were selected in accordance with the familiarity. Namely, an attempt was made to collect loanwords that are familiar to New Zealanders to some extent. As with 2.2.2.1 and 2.2.2.2, the line is 100mm long. Once again, the distance of the marked point from the left edge was employed as a value of subjective word frequency, that is, the point ranges between 0-100:

(6) Questionnaires for subjective word frequency

How often do you use or hear the following Māori words in your daily speech?

Please mark anywhere along the horizontal line.

1. Akaroa

Very Seldom ——————————————————— Very Often

As will be discussed below, the raw values were standardized within a speaker. The method is explained in 2.3.3. The bean plots of the z-scored values will be provided in Chapters 3-5.

2.3.2 Words' association with source language and its culture

Finally, participants were required to answer how strongly a target loanword is deemed to be associated with Māori. They rated this word-specific property by answering the following question. As with subjective word frequency, the linear scale was employed:

(7) Questionnaires for words' association with Māori

How strongly do you think the following words are associated with Māori? (Some words are associated with Māori very strongly. For example, I feel that *takahē* is not strongly associated with Māori but *hāngi* is more strongly associated with Māori.) Please mark anywhere along the horizontal line.

1. Akaroa

Very Weakly ——————————————————— Very Strongly

As with subjective word frequency, the raw values were z-scored. The standardization method is explained in what follows. The bean plots of the z-scored values will be provided in Chapters 3-5. The z-scored values are called *wordMaoriness*, which will be fitted in the statistical analyses in the following chapters.

One of the examiners asked whether this subjectively rated variable *wordMaoriness* may be affected by a variety of factors such as semantic properties and phonological structure. For example, one of the possible semantic factors may be core loanwords vs. cultural loanwords (Myers-Scotten 2002). Core loanwords refer to loanwords whose semantic concepts exist in the native lexicon (e.g., *Aotearoa* and *te reo*), while cultural loanwords refer to those not (e.g., *Tīmaru* and *tuatara*). Our data suggest that core loanwords have higher *wordMaoriness* in comparison with cultural loanwords. It is worth exploring exactly what type of factors determine *wordMaoriness* in future study.

2.3.3 Statistical analyses: z-scoring

The raw data obtained from these questionnaires was standardized by z-scoring within each speaker, because the ranges of subjectively rated values vary in accordance with

participants. Note that the formula for the z-score is *(x_i − mean) / standard deviation*, and it tells us how a data point x_i deviates from the mean for a particular speaker and enables us to compare two data points that come from different speakers. For example, Table 2.3 shows how words' association with Māori rated by Participant 9 is z-scored. The mean of the rated values within this speaker is 55.1 and the standard deviation is 31.6. Two loanwords *Akaroa* and *Aoraki* are rated as 11 points and 80 points respectively. Hence, the z-scored value of *Akaroa* is −1.39 (i.e., (11−55.1)/31.6), and that of *Aoraki* is 0.78 (i.e., (80−55.1)/31.6). Note that a positive z-score represents a data point higher than the mean, and a negative z-score represents a data point lower than the mean.

Target loanword	Raw value	Z-scored value
Akaroa	11	−1.39
Aoraki	80	0.78
harakeke	91	1.13
koru	58	0.09
kumara	34	−0.66
marae	94	1.22
Oamaru	10	−1.42
Timaru	3	−1.64
…	…	…
Whangarei	89	1.07

Table 2.3 Z-scoring of target loanwords in Experiment 2 within Speaker 9 (words' association with Māori)

These z-scored values will be fitted in the following statistical analyses rather than raw values. The z-scored values will be discussed in more detail with bean plots, when explaining Experiments 1-3 in the next three chapters.

Chapter 3 Likelihood of adaptation vs. importation I: Effect of topic

3.1 Introduction

As was clarified in Chapter 1, the aim of this thesis is to answer [RQ1] "*How are imported structure and adapted structure stored in the mind of a borrower and processed in the production of a loanword?*" This research question is addressed partly by answering [RQ1a] *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors*, that is, whether the variation is socially meaningful as in other sociolinguistic phenomena such as dialect shifts. This concrete research question leads to four specific questions, three of which are addressed in this chapter:

(1) Research questions addressed in this chapter

RQ2: "Is the likelihood of adaptation vs. importation affected by topic in speech?"

RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"

RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

Addressing these research questions develops our understanding of how adapted structure and imported structure are represented in the mind of a borrower. More specifically, we could test mainly the hypotheses about (0) representation of adapted structure and imported structure and (1) category activation in our theoretical framework (see 1.7). The results will suggest that variation in loanword phonology is socially meaningful.

As will be reviewed below, topic effects are well attested in the literature on sociolinguistic variation, but they have not, to our knowledge, been discussed in relation to loanword phonology. This chapter investigates the extent to which this effect extends to loanword phonology. In addition, other sociolinguistic variables (i.e., speakers' sociolinguistic properties and words' sociolinguistic properties) will also be explored. As was reviewed in Chapter 1, speakers' sociolinguistic properties have been discussed in previous literature about loanword phonology (e.g., Poplack & Sankoff 1984; Friesner 2009). However, the current study will explore wider aspects of speakers' sociolinguistic properties, as will be explained below. To the best of our knowledge, words' sociolinguistic properties have never been discussed (but see Lev-Ari & Peperkamp 2014), and this study will be the first study to explore this effect on loanword phonology.

This chapter consists of six sections. Section 3.2 reviews relevant parts of the theoretical framework constructed in Chapter 1, and deduces predictions relevant to the above research

questions. Section 3.3 describes the experimental design, acoustic analyses, and questionnaires. Section 3.4 shows the statistical results of the experiment. Section 3.5 discusses the effects of key variables on the likelihood of adaptation vs. importation, and Section 3.6 summarizes this chapter.

3.2 Background

3.2.1 Theoretical framework: exemplar strength and category activation

In Chapter 1, a theoretical framework was constructed on the basis of Exemplar Theory (Pierrehumbert 2001; 2002) and Message-Oriented Phonology (Hall et al. 2016; 2018). In this section, we will review some parts of the framework relevant to the three research questions. The hypotheses we will test in the current chapter are those regarding how imported structure and adapted structure are stored and activated in the mind of a borrower.

First of all, it is assumed that linguistic knowledge is constructed by representing both episodic memories (i.e., exemplars) and abstract representations (i.e., categories). Exemplars include fine-phonetic details with perceptual-acoustic values, and exemplars with similar phonetic values cluster together in the exemplar space, the result of which is that an abstract category is formed and represented by the density of the similar exemplars (Pierrehumbert 2001; 2002; Foulkes & Docherty 2006; Wedel 2006; Hay & Foulkes 2016; Todd et al. 2019). The categories may include non-linguistic categories such as gender and social class as well as linguistic categories such as phonemes and words. These categories and exemplars are cognitively linked in a complicated manner: an exemplar can be linked with various categories simultaneously and a category can be linked with other categories as well (see Pierrehumbert 2001; Foulkes & Docherty 2006; Docherty & Foulkes 2014). In the case of NZE loanword phonology, the following specific hypotheses were presented in the previous chapter: (0a) exemplars including imported structure [ɾ] and adapted structure [ɹ] are both stored in the mind of a NZE speaker, and the phonological categories [ɾ] and [ɹ] are formed and represented in her mind, because both structures are frequently used in New Zealand English; (0b) the categories of adapted structure and imported structure are cognitively linked with each other, as they are variants of /r/-sounds in Māori loanwords; (0c) the imported structure [ɾ] is socially associated closely with a concept of "Māori," because imported structure is identical to the structure used in the Māori language and society. Figure 3.1 illustrates these hypotheses, see the discussion in 1.7.1 for the detail:

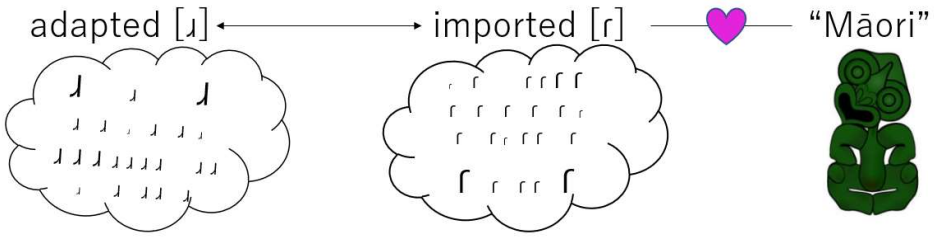


Figure 3.1 Category and exemplar association

Second, it is assumed that speakers begin speech production by activating a category they want to produce. The likelihood of activating a particular category is influenced by (a) the strength of the exemplars belonging to the category and (b) the activation of the relevant category. Exemplars have higher strength, when they are stored frequently and/or recently. That is, a category represented by exemplars stored frequently and/or recently is more likely to be activated due to its potential dominance, all else being equal (Pierrehumbert 2001; 2002). It is also known that a particular category may be activated due to the activation of other relevant categories. The current study assumes that the activation of a social category may raise the activation of a relevant linguistic category, the result of which is that the linguistic category is more likely to be activated (Hay et al. 2006; Hay & Drager 2010; Drager et al. 2010; Hay & Foulkes 2016). In the case of NZE loanword phonology, the following specific hypotheses were presented in the previous chapter: (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category (i.e., the imported structure is more likely to be activated, if it is used more frequently and/or recently, with the reverse true for the adapted structure); (1b) the activation of imported structure is more likely to occur when the social concept "Māori" is activated, as we hypothesized above that (0c) imported structure is closely associated with the social concept "Māori." Figures 3.2 and 3.3 illustrate these hypotheses, with more detail in 1.7.2.

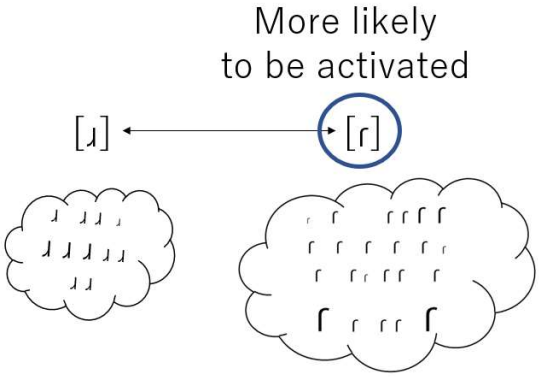


Figure 3.2 Potential likelihood of category activation

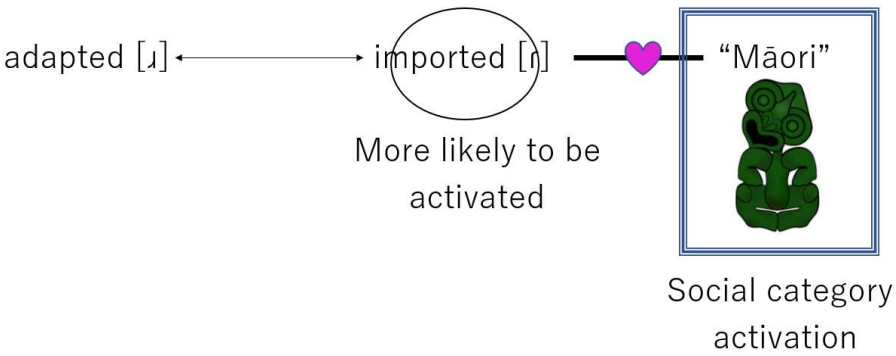


Figure 3.3 Activation of phonological category via activation of relevant concept

As for the activation of a social concept, it was hypothesized in the previous chapter that (1c) the social concept "Māori" may be activated by speech situations such as a topic in speech and a presented cultural image and (1d) speakers may potentially activate the social concept "Māori" when they have more positive attitudes towards Māori. These hypotheses are discussed in more details below.

Finally, a particular exemplar is chosen to be a production target. It was assumed in the previous chapter that (2a) an exemplar is chosen in accordance with the category (i.e., adapted structure or imported structure) selected during the category activation, that is, an exemplar belonging to the phonological category [ɹ] is chosen when the category [ɹ] is activated, whereas an exemplar belonging to the phonological category [ɾ] is chosen when the category [ɾ] is activated; (2b) an exemplar with higher strength is more likely to be chosen for production. As will be tested in Chapters 6 and 7, it is hypothesized that (3) the production target undergoes production biases, and finally (4) it is produced as a signal with a random noise, as seen in the discussion within 1.7.

3.2.2 Predictions

The aim of this sub-section is to review previous studies related to the three research questions, and deduce the predictions on the basis of our theoretical framework.

3.2.2.1 Topic effect

Although topic effects are yet to be discussed in relation to loanword phonology, the effects are well attested in the literature on sociolinguistic variation such as dialect shifts and style shifts. For example, Mendoza-Denton et al. (2003) discuss the phonetic realization of /ay/, which is realized as a monophthong [a:] in African American English, in the speech of Oprah Winfrey (an American media proprietor) in a TV show *The Oprah Winfrey Show*. They found that more African American English variants [a:] are produced when she introduces African American guests than when she introduces non-African American guests. To take another example, Love & Walker (2013) demonstrate that soccer fans produce more American English variants when they talk about American football than English soccer.

These topic effects can neatly be captured by Exemplar Theory (Mendoza-Denton et al. 2003; Walker 2014; Hay & Foulkes 2016). A topic in speech is hypothesized to activate a particular category or a concept that is closely related to the topic. For example, speaking about other African Americans may activate the concept "African American," and speaking about American football may activate the concept "United States." As was assumed above, the activation of a social concept may activate a linguistic category closely related with the social concept. For instance, the activation of the concept "African American" may raise the activation of a linguistic category formed by exemplars produced by African American speakers, and that of "United States" may raise the activation of a linguistic category represented by exemplars labelled as American English. As a result, exemplars with African American features and

American English features are more likely to be chosen and produced in accordance with the topics in speech. In this way, a topic in speech may activate a particular linguistic category via a social category that is closely related to the topic.

In our case, it can be hypothesized that (1c), when borrowers talk about something related to Māori in speech, the topic may activate the social concept "Māori." As was seen in Chapter 1, we crucially hypothesized that (0c) the imported structure [ɾ] is closely associated socially with the concept "Māori," and that (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated. It is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these hypotheses, we can deduce the following prediction that is relevant to RQ2:

Prediction 2: When a NZE speaker talks about something related to Māori in speech, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

3.2.2.2 Speakers' association with Māori

There is no doubt that the selection of a linguistic variant is influenced by speakers' social properties, and it has been demonstrated that language variation is socially motivated (Labov 1972; McEntegart & Le Page 1982; Bell 1984; Eckert 2000 among others). For example, Labov (1963) found that fishermen at Martha's Vineyard produce centralized /ay/, and Labov (1972) shows that speakers with a working-class background are more likely to realize /θ/ as [t] than those characterized as 'middle-class' in New York City. In order to account for sociolinguistic variation, some variationist studies regard speakers as passive users of the linguistic features associated with a particular social group (Wolfram & Schilling 2016: 301). In other words, the selection of sociolinguistic variants is determined by the exposure to a particular variant in the community to which a speaker belongs. The effect of exposure is supported by the fact that children acquire sociophonetic variation through the exposure to sociolinguistic variants produced by their parents and friends (Foulkes & Docherty 2006).

In addition to the exposure to sociolinguistic variation, speakers' agentivity is also an important factor in determining the selection of a sociolinguistic variant. Bell (2014: Ch.11) notes "speakers intentionally stylize linguistic features in order to call up associations with particular groups or identities." For instance, Eckert (2000) explored how teenagers in Detroit choose different linguistic variants of six vocalic variables and one syntactic variable. She found that the selection is not determined in accordance with their parents' socioeconomic status (i.e., their given social group), but determined in accordance with a local social category that a speaker wishes to affiliate with. To take another example, Drager et al. (2010) explored how NZE speakers accommodate with Australian English vowels. They demonstrated that NZE speakers are more likely to accommodate with Australian English vowels when they have more positive attitudes towards Australia. These studies suggest that the selection of a linguistic variant is determined not only by the exposure to a sociolinguistic variant but also by the

attitudes towards a social group or value. That is, the selection is sometimes agentive, and speakers may intentionally choose a linguistic variant in accordance with their intentional identity or attitude towards a social group.

The effects of exposure and attitudes can be expressed in a different manner using Exemplar Theory. The exposure effect can be accounted for by the potential strength of exemplars (see Foulkes & Docherty 2006). As linguistic knowledge is built up by representing in memory tokens of previously encountered speech, the storage of exemplars depends on daily speech. The more often a particular exemplar is stored through the frequent exposure to a variant, the higher the potential strength of the exemplar becomes. In the case of New York City English, working-class people may store the variant [t] of the variable /θ/ more often, as it is used more frequently in the speech surrounding the speakers. Consequently, exemplars with [t] have higher strength in the cognitive systems of the working-class people, and they are more likely to be chosen generally in production. In this way, the strength of exemplars is updated by speech surrounding a speaker, and the selection of linguistic variants is largely affected by the society to which the speaker belongs.

On the other hand, the attitude effect can be captured by the activation of the relevant category. Drager et al. (2010) note that "The degree of activation depends on the speaker's attitudes and social biases. Positive attitudes and biases toward a social group result in activation of phonetic representations indexed to the social group." That is, speakers may potentially activate a social concept, when they have more positive attitudes towards the social group or wish to associate with the social group, and consequently they are more likely to activate and produce exemplars associated with the social concept (see also Drager 2009: Ch.6). In the case of Drager et al. (2010), NZE speakers may potentially activate the social concept "Australia," when they have more positive attitudes towards Australia. As a result, they are more likely to activate and produce vocalic variants associated with "Australia," and accommodate with Australian vocalic variants.

In the current thesis, we will explore the effects of both exposure and attitudes on the likelihood of adaptation vs. importation. In what follows, we will deduce predictions about each type of associational effect. It can be hypothesized that if speakers have a stronger relationship with Māori, they may be more likely to be exposed to imported structure and have more opportunities to store exemplars with imported structure, and exemplars with imported structure have higher strength. The reason is that imported structure is considered more likely to be used in the Māori language and community, as it is the structure identical to te reo Māori, and the usage of the structure has been promoted by the Māori community. We crucially hypothesized that (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category, and assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these hypotheses, the following prediction related to RQ4 can be deduced:

Prediction 4a: If a NZE speaker has a stronger relationship with Māori (i.e., the source

language and its culture), the speaker may be exposed to more imported structure and store more exemplars with imported structure, the result of which is that she is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

As was seen above, a speaker may activate a social concept when she has positive attitudes towards the social concept or the relevant social group (Drager et al. 2010). In the case of NZE loanword phonology, we could hypothesize that (1d) speakers may activate the social concept "Māori" when they have more positive attitudes towards Māori. In addition, we specifically hypothesized that (0c) the imported structure [ɾ] is socially associated closely with the concept "Māori," and therefore (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated. It is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. On the basis of these hypotheses, the following prediction can be put forward:

Prediction 4b: If a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori," and consequently she is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

As was reviewed in the previous chapter, some previous literature about loanword phonology has already discussed borrower's relationship with the source language and source language speakers (Haugen 1950; Poplack et al. 1988; Friesner 2009; Lev-Ari et al. 2014; Aktürk-Drake 2015; 2016). The current study explores borrower's attitudes towards the source language and culture and borrower's relationship with the culture of source language speakers as well. By exploring wider aspects of speaker-specific properties, it can be clarified exactly how loanword phonology is affected by borrower's association with the source language and culture.

3.2.2.3 Words' association with Māori

It has been demonstrated that word-specific variation in phonetic implementation exists (Pierrehumbert 2001; 2002; Walker & Hay 2011; Seyfarth 2014; Hay & Foulkes 2016). For example, Seyfarth (2014) demonstrates that words that tend to appear in predictable contexts are more likely to be realized with reduced phonetic forms even if they do not appear in contexts that trigger reduction. To take another example, Hay & Foulkes (2016) show that words likely to be used by younger speakers are more likely to undergo innovative allophonic processes, whereas words likely to be used by older speakers have higher probability to undergo conservative allophonic processes.

This word-specific variation can be neatly captured by exemplar-based approaches. As was seen above, linguistic knowledge is built by a cloud of tokens encountered within speech, that is, mental representations of words are continuously updated based on experience. In the case of Hay & Foulkes (2016), words used more often by younger speakers may be heard with innovative allophonic variants, whereas words used more frequently by older speakers may be heard with conservative allophonic variants. Consequently, representations of words used more

commonly by younger speakers are updated with innovative variants, while representations of words used more often by older speakers are updated with conservative variants. As a result, as for words more often used by younger speakers, exemplars with innovative allophonic variants have higher strength than exemplars with conservative variants, and the innovative patterns are more likely to be produced. The reverse is true for words of elders.

Given that imported structure is used more often within the Māori community, imported structure may be heard more often in loanwords strongly associated with Māori than those weakly associated with Māori. Consequently, loanwords strongly associated with Māori may be more likely to be stored with imported structure in memory, and exemplars with imported structure have higher strength amongst the exemplars associated with these lexical categories. It is specifically hypothesized that (1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category, and it is assumed that (2a) an exemplar is chosen in accordance with the category selected in the category activation. The following prediction can be generated:

Prediction 5: If a loanword is more strongly associated with Māori (i.e., the source language and its culture), the loanword may more often be stored with imported structure, the result of which is that the loanword is more likely to be produced with imported structure [ɾ] than adapted structure [ɹ].

3.3 Methodology

This section illustrates the research design employed in the current chapter. In order to test the above four specific predictions, a passage reading task (Experiment 1) was run. In this experiment, participants were asked to read passages about Māori and general leisure in New Zealand. The manipulation of topics in passages allows us to test Prediction 2. After the experiment, the participants were asked to fill in questionnaires (see Chapter 2), which are about speaker-specific properties and word-specific properties. These questionnaires enable us to test Predictions 4 and 5.

3.3.1 Participants

32 NZE speakers participated in this task. They are aged between 18-35. 26 speakers are female, and 6 speakers are male. All the speakers identify themselves primarily as Pākehā rather than Māori. They are monolingual speakers without any other language spoken in their environment in their childhood. It was ensured that they were not fluent bilinguals in te reo Māori, because fluent knowledge of Māori may result in code-switching rather than lexical borrowing. No speaker reported that they can speak te reo Māori well or very well, according to their answers of questionnaires in Section D (see Appendix C). They were recruited at the University of Canterbury and via websites. All the participants were interviewed by the author. Note that the participants in Experiment 1 also participated in Experiment 2 before answering questionnaires. They received a 15 NZD voucher at the end of the experiment.

3.3.2 Experiment 1: material and procedures[5]

All the participants were tested individually in a sound booth at the University of Canterbury. They were asked to read aloud 10 short passages, four of which are passages about Māori (hereafter referred to as Māori passages), four of which are passages about leisure in New Zealand (hereafter referred to as neutral passages), and two of which are filler passages (see Appendix D). This manipulation of topics enables us to test the effects of topics on the likelihood of adaptation vs. importation. The Māori passages and the neutral passages both include the following target loanwords, which are assembled into four groups:

(1) Four groups of target Māori loanwords
Group A: Rotorua, Taranaki, Whangarei Group B: Akaroa, Aoraki, Kaikoura, Moeraki
Group C: Oamaru, Tauranga, Timaru, Tokoroa Group D: Maruia, Paeroa, Porirua, Rangiora

All these 15 Māori loanwords are place names, which allow us to manipulate topics naturally. They all include word-medial rhotics /r/, of which the realizations can be classified into adapted structure [ɹ] or imported structure [ɾ] (see 1.6.3). In the current study, only the word-medial rhotics are analysed, and the word-initial rhotics in *Rangiora* and *Rotorua* are not discussed. Note that *Porirua* has two word-medial rhotics, which are annotated separately. These target loanwords were mentioned twice within a passage. Hence, 2,048 /r/ tokens are supposed to be collected (16 word-medial /r/ x 2 times mentioned in a passage x 2 topics x 32 participants). It was made sure that the target loanwords occur sentence-medially.

The stimuli were presented using *E-prime 2.0 software* (Psychology Software Tools, Pittsburg, PA). Each participant was asked to read the passages in a natural way. At the beginning of each trial, the passage appeared on the screen of a computer, and remained there for the rest of the trial. After the participants pronounced the whole passage, they pressed the space bar and the next passage appeared on the screen. They repeated this procedure until they finished reading all the ten passages (four Māori passages, four neutral passages, and two filler passages).

The order of the passages was pseudo-randomized using R (R Core Team 2016) in the following way. The passage topic alternated every two passages, that is, participants read two Māori passages after reading two neutral passages, or they read two neutral passages after reading two Māori passages. The order was counter-balanced, i.e. half the participants began with Māori topics and the other half began with neutral topics. In addition, it was ensured that the first four passages included all the loanwords belonging to the four groups. This combination was also counter-balanced, i.e., half the participants pronounced Group A and

[5] This experiment was pre-registered using AsPredicted (https://aspredicted.org/index.php). The ID is #5095. Note that the methodology and the prediction in this thesis are identical to the preregistration, but the theoretical motivation was elaborated further.

Group B loanwords in Māori passages first, and the other half pronounced Group A and Group B loanwords in neutral passages first. There were two filler passages between the first four target passages and the second four target passages, and there was a short break between the first five passages and the second five passages. The procedure of the passage-reading task is generalized in Table 3.1:

Participants A (P1, P5, P9, P11..)	Participants B (P2, P6, P10, P14..)	Participants C (P3, P7, P11, P18..)	Participants D (P4, P8, P12, P19..)
2 Māori passages with Groups A & B	2 Māori passages with Groups C & D	2 neutral passages with Groups A & B	2 neutral passages with Groups C & D
2 neutral passages with Groups C & D	2 neutral passages with Groups A & B	2 Māori passages with Groups C & D	2 Māori passages with Groups A & B
1 filler passage	1 filler passage	1 filler passage	1 filler passage
[short break]	[short break]	[short break]	[short break]
1 filler passage	1 filler passage	1 filler passage	1 filler passage
2 Māori passages with Groups C & D	2 Māori passages with Groups A & B	2 neutral passages with Groups C & D	2 neutral passages with Groups A & B
2 neutral passages with Groups A & B	2 neutral passages with Groups C & D	2 Māori passages with Groups A & B	2 Māori passages with Groups C & D

Table 3.1 Procedure in Experiment 1

After they finished the whole passage-reading task, they moved to the word-list reading task (Experiment 2) and filled in the questionnaires. The design of the word-list reading task and the result will be reported in the next chapter.

3.3.3 Questionnaires

As was discussed in Chapter 2, questionnaires were designed to examine speaker-specific properties and word-specific properties. More specifically, participants were asked to answer questions about their association with Māori (e.g., attitudes towards the Māori language and culture and relationship to Māori language, culture, and people). In addition, they were asked to rate the subjective word frequency of target loanwords and the association of target loanwords with Māori.

3.3.3.1 Speakers' association with Māori

As was explained in Chapter 2, the participants answered 27 questions about their relationship with Māori and attitudes towards Māori. Their answers were reduced to three variables through principal component analyses:

(2) Meanings of three factors as a result of PCA

PC-attitude: attitude towards Māori culture and language

PC-culture: relationship with Māori culture and language, and individual proficiency

PC-people: relationship with Māori people, and neighbourhood proficiency

These three principal components will be explored in the following statistical analyses.

3.3.3.2 Words' association with Māori and word frequency

As was stated above, the current thesis predicts that loanwords closely associated with Māori are more likely to undergo importation than those weakly associated with Māori. In order to measure the words' association with Māori, the participants subjectively rate how strongly a target loanword is deemed to be associated with Māori (see 2.3.2 for the detail). The raw data obtained from these questionnaires were standardized by z-scoring within each speaker, because the ranges of subjective frequency vary in accordance with participants (see 2.3.3). These z-scored values will be fitted in the following statistical analyses. The following peanut plot (Figure 3.4) indicates the distribution of the z-scored values, and the inside dot indicates the mean value across the speakers. For example, many participants feel that *Aoraki* is strongly associated with Māori while *Timaru* is weakly associated with Māori. The strong association of *Aoraki* with Māori may be because this place can also be called *Mount Cook*, which has been used within Pākehā community for a long time. As for the three place names weakly associated with Māori (*Timaru*, *Oamaru*, and *Akaroa*), the places are close to the University of Canterbury (where the study took place), and thus the places may be more assimilated to the society of the participants.

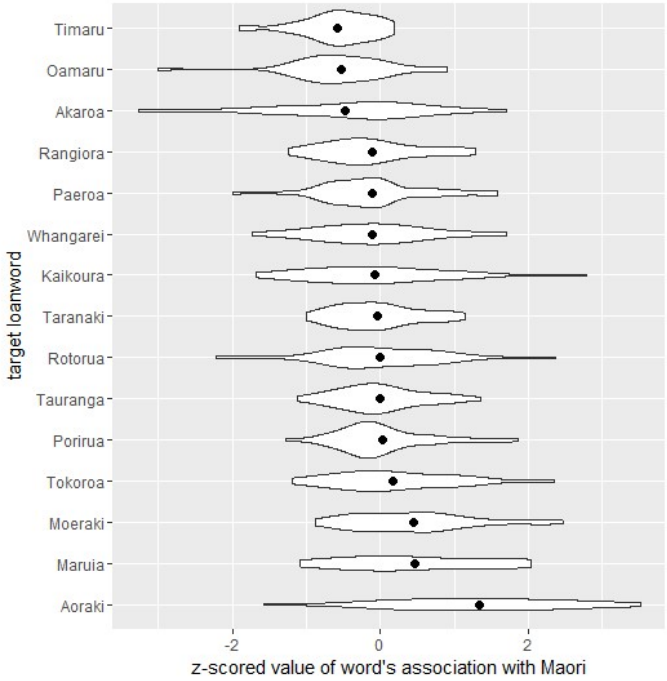


Figure 3.4 Peanut plot for z-scored words' association with Māori

In addition, word frequency is also examined, because it has been pointed out by previous literature that word frequency may affect the likelihood of adaptation vs. importation (Poplack & Sankoff 1984; Friesner 2009; 2010), as was reviewed in Chapter 1. As for Māori loanwords, there are not a large number of tokens in any corpora, and thus it is difficult to measure their objective word frequency. Hence, subjective word frequency is employed in this study. Each participant was required to rate word frequency of target loanwords employed in the experiments (see 2.3.1 for the detail). The raw data obtained from these questionnaires were standardized by z-scoring within each speaker, as with words' association with Māori. These z-scored values will be fitted as control variables in the following statistical analyses. The following peanut plot (Figure 3.5) indicates the distribution of the z-scored values, and the inside dot indicates the mean value across the speakers. For example, many participants feel that *Rangiora* is frequently used in daily speech while *Maruia* is rarely used in daily speech. Unsurprisingly, the words rated as high-frequency tend to be close to the University of Canterbury (e.g., *Rangiora*, *Kaikoura*, and *Timaru*).

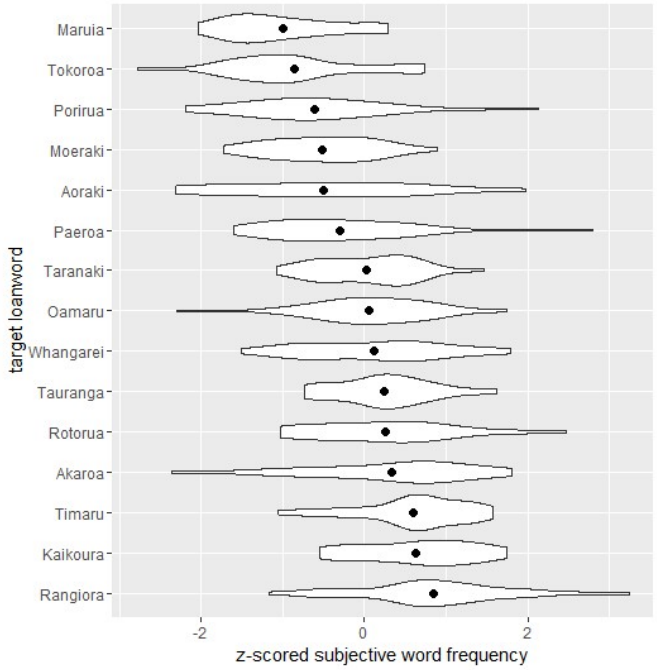


Figure 3.5 Peanut plot for z-scored subjective word frequency

One might wonder whether words' association with Māori and subjective word frequency correlate negatively. Pearson's correlation test was performed, and it was found that the correlation is almost none (r=−0.19).

3.3.4 Acoustic analyses

This study is mainly based on the acoustic visualization to classify the realization of /r/ into imported structure [ɾ] and adapted structure [ɹ]. As stated below, 91% of the /r/ realizations

were annotated acoustically with a use of spectrograms. The acoustic classification was performed using Praat (Boersma & Weenink 2016).

Following previous literature (German et al. 2013), voiced sounds with clear consonantal edges in sound spectrograms were annotated as taps [ɾ]. Their domains were usually determined on the basis of soundwaves. In particular, domains without vocalic waves (i.e. major periodic waves) were labelled. The domain is usually determined in accordance with sound waves, but based on spectrograms in minor cases. The duration of taps is an important variable in Chapter 6, and thus it is subsequently clarified in more detail how the domain was determined:

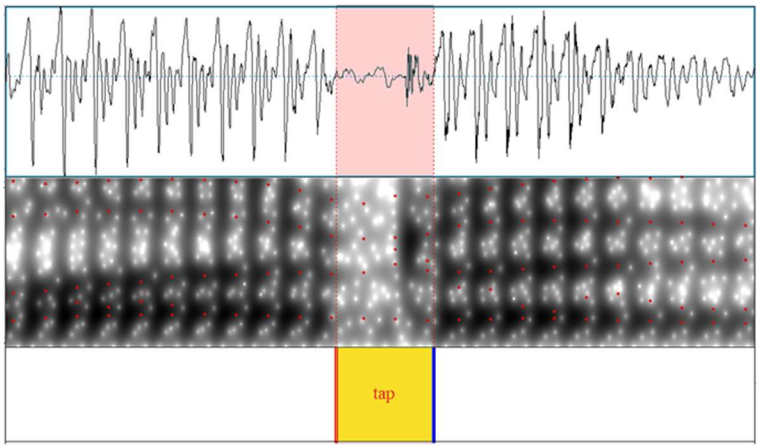


Figure 3.6 Sample spectrogram of imported structure ("Oamaru" by P3)

Voiced sounds without clear consonantal edges in sound spectrograms were classified as approximants [ɹ] if their F3 is lowered. It is well-known that retroflex approximants lower F3 (Olive et al. 1993: Ch.7; Ladefoged 2006: 196; Hay & Maclagan 2012; Lawson et al. 2011). It is not easy to exactly determine the duration of [ɹ], as the formant structure is continuant with surrounding vowels. We made an attempt to annotate the domains including consistent F2 around the F3-lowering in most cases, because F2 is known as an indicator of consonantal domains in many phonetic studies (see Lavoie (2004: 69) and her citations). For example, the area which included consistent rises in F2 was annotated in Figure 3.7. However, we must admit that the annotation of the boundaries is still arbitrary to some extent. In fact, Umeda (1977) also notes "Some consonants such as /h/, /r/, /w/, /y/, and word-final /1/ were totally impossible to measure." The boundary between vowels and approximants [ɹ] is always continuous, and it is not easy to establish objective criteria to define the boundary. Despite this, Chapter 7 will discuss F3 values of approximants on the basis of these annotations, which should estimate the domain the domain.

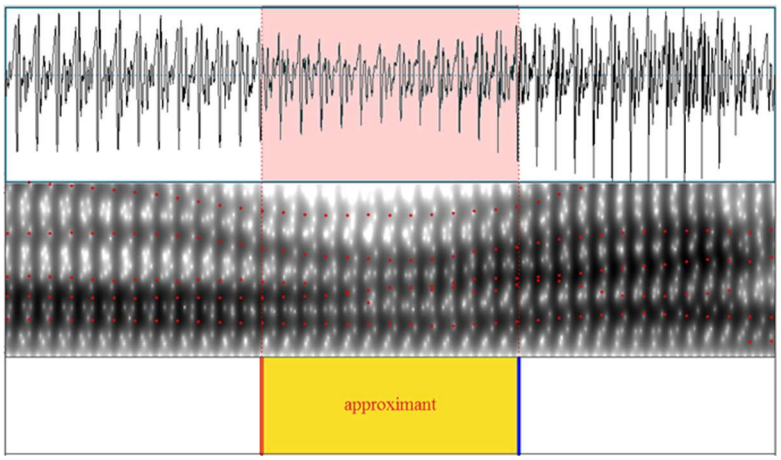


Figure 3.7 Sample spectrogram of adapted structure ("Moeraki" by P5)

The remaining productions (e.g., voiced sounds without clear consonantal edges and without lowered F3) were classified impressionistically into [ɾ], [ɹ], and deleted sound (or others). The classificatory process and the total number of each class can be summarized as in (3).

(3) Classification of /r/ realizations

If voiced sounds have clear consonantal edges, then they are acoustically classified as [ɾ].

If voiced sounds have no clear consonantal edges with lowered F3, then they are acoustically classified as [ɹ].

If voiced sounds have no clear consonantal edges without lowered F3, then they are impressionistically classified as [ɾ], [ɹ], or deleted sound (or others).

3.4 Results

The aim of this section is to illustrate the results of the experiment, and show the statistical analyses.

3.4.1 Number of observations

As was explained above, 2,048 tokens of /r/ were supposed to be collected. 17 tokens were excluded because of mispronunciation or disfluency. 107 tokens were removed, because participants did not know some loanwords (i.e., subjectively rated as 0 with regards to the participants' word frequency). Finally, the following tokens were left, and they were classified as follows:

Annotation	Number
Acoustically identified tap [ɾ]	848 (44%)
Acoustically identified approximant [ɹ]	904 (47%)
Impressionistically identified tap [ɾ]	108 (5.7%)
Impressionistically identified approximant [ɹ]	14 (0.7%)
Impressionistically deleted sounds (or others)	50 (2.6%)
SUM	1,924

Table 3.2 Total number of observation

3.4.2 Variables

3.4.2.1 Response variable: adaptation vs. importation

The response variable is a binary variable: adapted structure [ɹ] vs. imported structure [ɾ]. As was discussed in the preceding section, the realizations of /r/ were classified into the five classes (acoustically identified [ɹ], acoustically identified [ɾ], impressionistically identified [ɹ], impressionistically identified [ɾ], and impressionistically deleted sound). For the sake of this study, the impressionistically deleted sounds (only 2.6% of the whole dataset) were excluded from our analyses. In addition, acoustically identified tokens and impressionistically identified tokens were collapsed into a single class (either adapted structure or imported structure), because logistic regression analyses can only handle binary variables. As a result, 918 tokens with adapted structure (48.9%) and 956 tokens with imported structure (51.1%) are statistically analysed.

3.4.2.2 Key predictors: topics and association with Māori

The variable of most interest is a binary variable *topic* (Māori topic vs. neutral topic). As stated above, the experiments were designed to make sure that participants read passages about Māori and general leisure. The tokens produced in Māori passages were coded as Māori topic and those produced in neutral passages were coded as neutral topic. As some participants began with Māori passages and the others began with neutral topic, *firstTopic* (Māori topic vs. neutral topic) is also explored. The tokens produced by speakers beginning with Māori passages were coded as Māori, and those produced by those beginning with neutral passages were coded as neutral.

In addition, the potential associations of speakers with Māori are also key factors. As stated in the preceding section, their associations with Māori were measured through the questionnaire, and they are mostly captured by the three principal components: *PC-attitude* (attitude towards Māori culture and language), *PC-culture* (relationship with Māori culture and language and individual proficiency in te reo Māori), and *PC-people* (relationship with Māori people and neighbourhood proficiency in Māori). The effects of these numeric variables are examined below.

Finally, a word's association with Māori is also a variable of interest. As was stated above, this variable is measured through the questionnaire, and each speaker was asked to rate how strongly a loanword is associated with Māori. The ratings were standardized within each speaker, and the standardized numeric variables are further on examined. This variable is treated as *wordMaoriness* in our data frame.

3.4.2.3 Control variables

In addition to the variables of interest, the following control variables are also examined. First, subjective word frequency is examined. As was reviewed in Chapter 2, it has been pointed out by previous literature that loanwords are more likely to be adapted as they are used more frequently (Poplack & Sankoff 1984; Friesner 2009; 2010). As stated above, word frequency was rated by each participant in the current study. This subjective word frequency was z-scored within each speaker, and the standardized values are treated as *subjFreq* in our statistical analyses.

As was reviewed in Chapter 2, it is also known that the proficiency of the source language influences the likelihood of adaptation vs. importation (Haugen 1950; Poplack et al. 1988; Friesner 2009; Lev-Ari et al. 2014; Aktürk-Drake 2015; 2016). Following previous literature, we will examine two types of proficiency. Individual proficiency refers to that of a borrower herself, and neighbourhood proficiency refers to that of a community to which a borrower belongs. However, PCA suggests that the individual proficiency correlates with "relationship with Māori culture and language" (*PC-culture*), and the neighbourhood proficiency correlates with "relationship with Māori people" (*PC-people*). That is, a participant closely related with Māori culture and language is likely to have a higher level of individual Māori proficiency, and a participant closely related with Māori people is likely to have a higher level of neighbourhood Māori proficiency. Hence, our data cannot tease apart the association of a speaker with Māori and the proficiency of Māori, and these properties will be analysed together. Recall that it was made sure that all the participants cannot speak te reo Māori fluently in the current study. Hence, individual proficiency does not contribute to *PC-culture* so strongly. In addition, all the participants do not belong to a community in which te reo Māori is spoken, as will be discussed below.

As all the target loanwords are place names, the places which speakers come from and the places which a loanword refers to are also taken into account. These two variables are treated as *wordPlace* and *speakerPlace* respectively, and they are binary variables (North Island vs. South Island). As the North Island has more Māori people, speakers from the North Island may store more imported structure and produce imported structure more frequently. In the same way, words referring to the North Island may be stored with imported structure more often, and produced with imported structure.

Five phonological variables (*folSt*, *precSt*, *folBr*, *precBr*, and *NofSeg*) are also examined. *folSt* is a binary variable (following vowel is main-stressed vs. not main-stressed); *precSt* is a

binary variable (preceding vowel is main-stressed vs. not main-stressed); *folBr* is a binary variable (there is a prosodic break immediately after the target loanword vs. no break); *precBr* is a binary variable (there is a prosodic break immediately before the target loanword vs. no break); *NofSeg* is a continuous variable (number of segments in loanwords). These variables are not expected to affect the likelihood of importation. However, they are expected to affect the duration of imported structure, and the duration is another research question we will address later in this thesis (see Chapter 6). This is why these variables are included within our data frame.

Finally, three experimental variables (*session*, *mention*, and *SpRate*) are also examined. *session* is a binary variable (produced in the first session (before the short break) vs. the second session (after the short break)); *mention* (mentioned first in a passage vs. second in a passage); *SpRate* (syllables per second). These variables were also expected to show no significant effects on the likelihood of adaptation vs. importation, but they were expected to show significant effects on the duration of imported structure. The duration is another property which is investigated later in this thesis, and thus these variables were also included within our data frame. Table 3.3 shows a list of the predictors examined in the following statistical analysis.

topic	Current reading passage is Māori vs. neutral (binary)
firstTopic	First reading passage is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori culture and language (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
subjFreq	Subjective word frequency (numeric)
wordPlace	Place referred to by a target loanword is in the North Island vs. the South Island (binary)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folBr	Target loanword is followed by a prosodic break or not (binary)
precBr	Target loanword is followed by a prosodic break vs. not (binary)
NofSeg	Number of segments within a target loanword (numeric)
session	Pronounced in the first session (before a break) vs. the second (binary)
mention	Mentioned first within a passage vs. second (binary)
SpRate	Syllables per second (numeric)

Table 3.3 List of variables examined in statistical analysis

3.4.3 Logistic regression analyses

The 1,874 tokens of /r/-sounds were hand-fitted into a mixed-effects logistic regression model with bobyqa optimizer using the *glmer* function in the *lme4* library (Bates et al. 2015) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 7 variables (*PC-people*, *subjFreq*, *folSt*, *precBr*, *NofSeg*, *mention*, and *SpRate*) were removed one-by-one through pairwise comparisons of models with and without each variable. As for these 7 variables, their interactions with the other variables were not examined, because the model including their interactions did not converge well and their p-values were not significant at all. Then, backward elimination was run manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the remaining 10 variables. The elimination was based on p-value, that is, either a single effect or an interaction with the highest p-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was implemented. Through this process, three variables (*speakerPlace*, *precSt*, and *folBr*) were removed. Finally, by-participant random slopes for *wordMaoriness* and *session* and by-word random slopes for *PC-attitude* were added to the model, as they improve the model. Although we attempted to fit random slopes for all the variables in the model, the other variables did not improve the model or the model did not converge well. After the addition of the three types of random slopes, three variables (*PC-culture*, *wordMaoriness*, and *wordPlace*) were removed, as their p-values became higher than the threshold of .05. A Variance Inflation Factor (VIF) test was performed on the model, and all VIF scores were below 4, which suggests that there is no multicollinearity in the model. The best-fitted model was found to be as in Table 3.4. Note that the reference level is set as `topic neutral`, `session First`, and `firstTopic neutral`.

adap/imp ~ PC-attitude+topic+session+firstTopic+topic:session+topic:firstTopic[6]

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.0172	0.8502	-2.373	0.017660	*
PC-attitude	1.7165	0.4956	3.464	0.000533	***
topic Maori	2.5085	0.3218	7.794	6.48e-15	***
session Second	1.4084	0.2909	4.841	1.29e-06	***
firstTopic Maori	0.1478	1.0805	0.137	0.891177	
topic Maori:session Second	-0.9698	0.3554	-2.729	0.006357	**
topic Maori:firstTopic Maori	-1.7942	0.3410	-5.262	1.42e-07	***

Table 3.4 Best-fitted model as result of backward elimination

[6] One of the examiners suggested that it is worth exploring a subset including only acoustically identified tokens. It was found that the significance of these variables is basically identical even when only acostically identified tokens are fitted into the model.

The response variable (adapted structure [ɹ] vs. imported structure [ɾ]) is dummy-coded (i.e. 0 is given to the adapted structure [ɹ] and 1 is given to the imported structure [ɾ]) in the above model. Hence, positive slopes indicate higher likelihood of choosing imported structure, and negative slopes indicate higher likelihood of selecting adapted structure. The *topic* coefficient is positive and significant in the best-fitted model. As neutral passages are selected as the baseline level, it suggests that NZE speakers are more likely to produce imported structure [ɾ], when they read passages about Māori. Figure 3.8 shows the raw probability of imported structure in accordance with a topic of a reading passage. In general, the importation probability is 8.6% higher given a Māori passage (55.3%) than when given a neutral passage (46.7%):

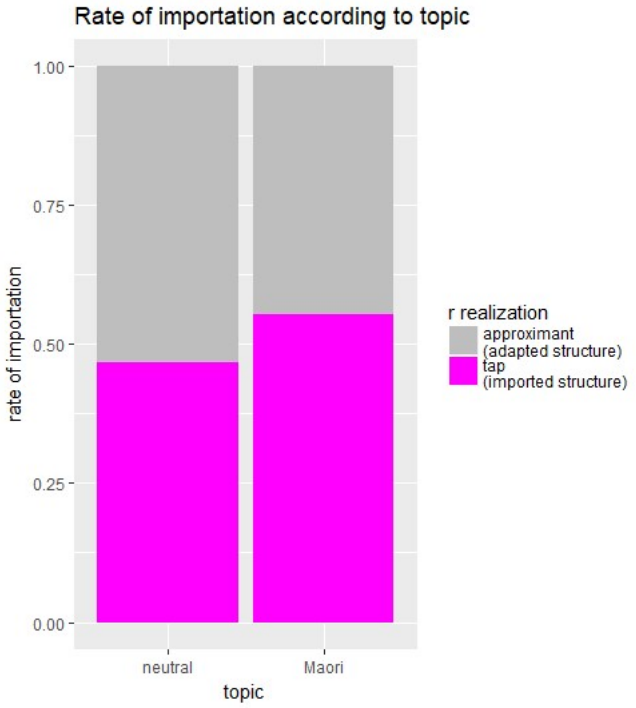


Figure 3.8 Likelihood of adaptation vs. importation depending on topic

As two significant interactions of *topic* with other variables are observed, let us consider the interactions. The interaction between *topic* and *session* indicates that the magnitude of the topic effect is significantly smaller in the second session than in the first session (β=-0.96, z=-2.72, p<0.01). This interaction is illustrated in Figure 3.9. The left-hand figure illustrates the raw probability, and the right-hand figure illustrates the probability predicted by the best-fitted model. This is why the subsets of data including tokens produced in the first session and those produced in the second session were also explored. Then, the effect of *topic* was still found to be significant in both the first session (β=2.75, z=7.1, p<0.001) and the second session (β=1.08, z=3.11, p<0.01).

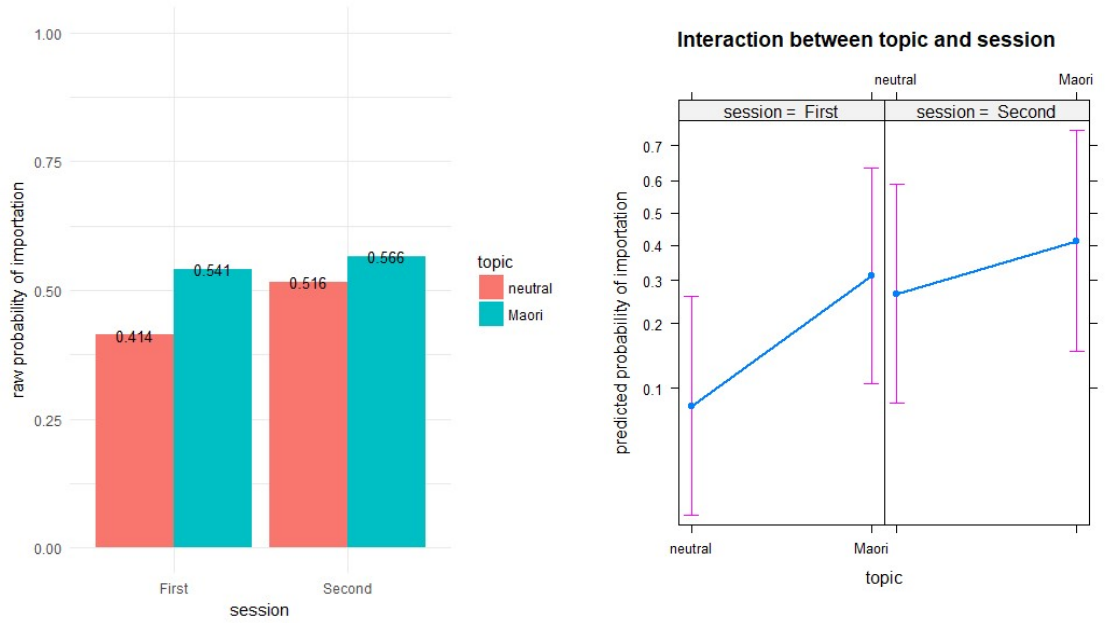


Figure 3.9 Interaction between topic and session: raw probability (left) and model prediction (right)

The other interaction between *topic* and *firstTopic* suggests that the effect of *topic* is stronger when participants begin with neutral passages than when participants begin with Māori passages. Once again, this interaction is illustrated by Figure 3.10. The subset analysis was performed, and it was found that *topic* is significant when speakers begin with neutral passages (β=2.92, z=7.5, p<0.001) while *topic* is not significant when speakers begin with Māori passages (β=0.27, z=0.9, p=0.36).

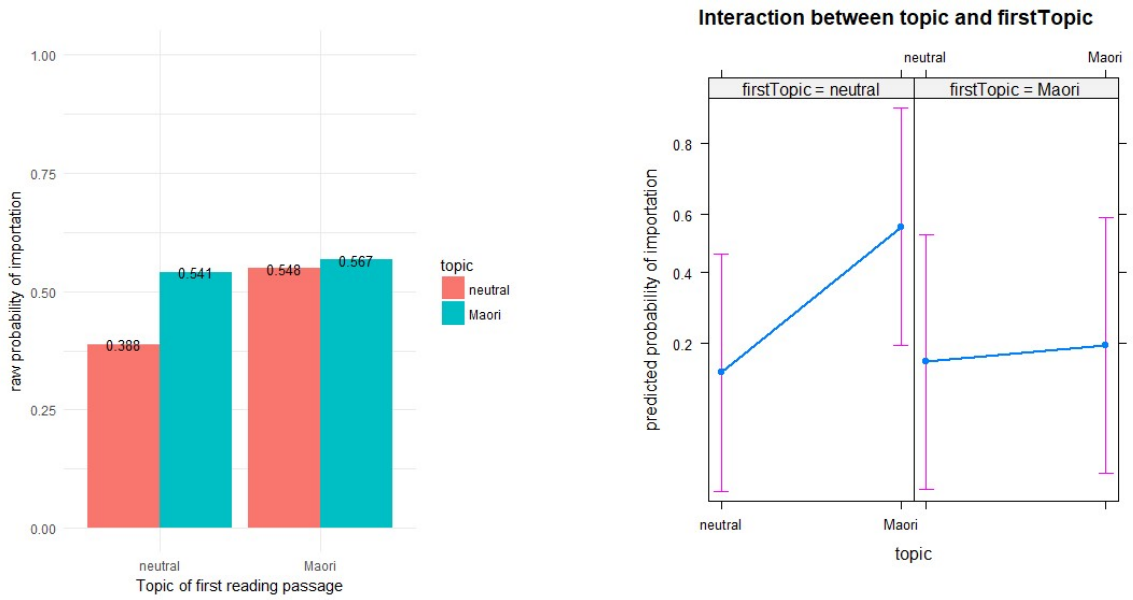


Figure 3.10 Interaction between topic and firstTopic: raw probability (left) and model prediction (right)

In addition, the speakers' potential association with Māori is also found to affect the likelihood of importation to some extent. The *PC-attitude* coefficient is positive and highly significant (β=1.71, z=3.46, p<0.001). As *PC-attitude* means "positive attitudes towards Māori culture and language," this coefficient indicates that imported structure is more likely to be produced by speakers with more positive attitudes towards Māori culture and language. The *PC-culture* was removed from the best-fitted model, as its p-value is 0.08. In fact, *PC-culture* was significant (p<0.05) unless by-word random slopes for *PC-attitude* were added to the model. The *PC-culture* did not achieve sufficiently significant effects, but the slope is positive and it might imply that speakers strongly related with Māori culture and language tend to use imported structure more often. On the other hand, *PC-people* was not significant at all (p=0.31). *speakerPlace* was not significant but does trend (p=0.07). The direction indicates that North Islanders are more likely to use imported structure than South Islanders.

Next, words' association with Māori is not found to be significant (p=0.11). Note that *wordMaoriness* was significant (p<0.001) unless by-speaker random slopes for *wordMaoriness* were added to the model and the direction was positive. The direction was as predicted, i.e., words strongly associated with Māori are more likely to be produced with imported structure. *wordPlace* was not significant but does trend (p=0.07). The direction suggests that place names in the North Island are pronounced with imported structure more often.

As for other control variables, only *session* shows a significant effect (p<0.001). As the reference level is the first session and the slope is positive, this effect suggests that speakers are more likely to produce imported structure after a short break, that is, as the experiment progresses.

As a whole, the variables showing significant effects or showing a trend are as follows. Variables showing trends are shaded in Table 3.5:

topic	When a passage is about Māori, speakers are more likely to produce imported structure (p<0.001). However, speakers beginning with neutral passages do not show this topic effect (p=0.36).
PC-attitude	Speakers with more positive attitudes towards Māori are more likely to produce imported structure (p<0.05).
PC-culture	Speakers strongly related with Māori culture and language are more likely to produce imported structure (p=0.08).
speakerPlace	North Islanders are more likely to produce imported structure (p=0.07).
wordPlace	Loanwords referring to places in the North Island are more likely to be produced with imported structure (p=0.07).
session	Speakers are more likely to produce imported structure in the second half of the experiment than in the first half of the experiment (p<0.001).

Table 3.5 Summary of finding in Experiment 1

3.5 Discussion

The aim of this section is to discuss the statistical results in relation to our theoretical framework. In all, our dataset shows that NZE speakers import non-native structure quite often. In our dataset, there are 918 tokens with adapted structure (48.9%) and 956 tokens with imported structure (51.1%). As we examined only young speakers aged between 18-35, it is still unclear whether this tendency is observed in overall NZE speech including older speakers. At least, our result suggests that young NZE speakers are likely to import non-native structure in their production of Māori loanwords. Figure 3.11 illustrates the importation rate according to a speaker:

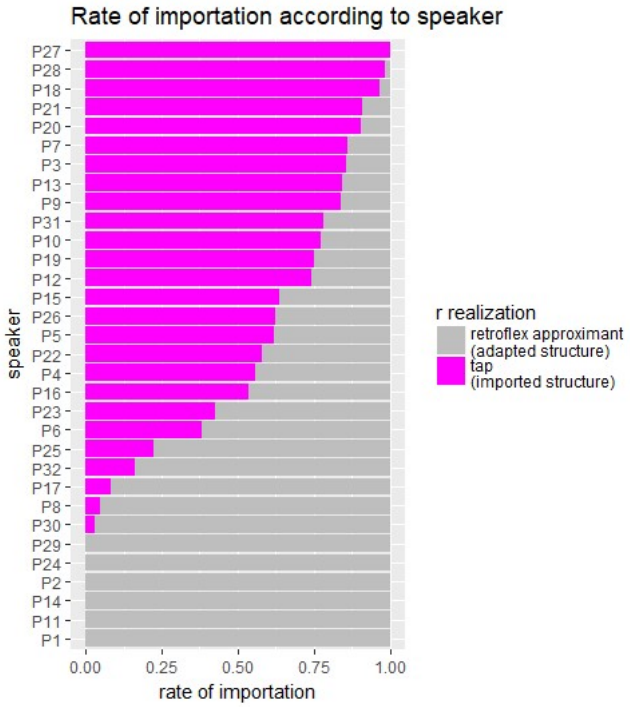


Figure 3.11 Rate of importation according to speaker

As for control variables, all the phonological variables were not significant as expected. Although previous literature demonstrates that higher frequency words are likely to be adapted (Haugen 1950), our result did not show this effect. The reason might be that all the words examined in this experiment are place names and they all have a low frequency in daily usage. For another reason, we employed subjectively rated word frequency as a predictor. Lev-Ari et al. (2014) also report that subjective word frequency is not a significant predictor. The proficiency of the source language is known to affect the likelihood of adaptation vs. importation (Poplack et al. 1988). It was found that *PC-culture* shows a trend (p=0.08), and this could be interpreted to mean that speakers with higher individual proficiency are more likely to use imported structure. However, we believe that the effect of individual proficiency is not very robust in our dataset. The reason is that the participants are not fluent bilingual speakers of Māori, and reported that they cannot speak te reo Māori fluently, see the discussion in 2.2.

In fact, the factor loading of individual proficiency on *PC-culture* is relatively low (−0.54). The other two control variables *speakerPlace* and *wordPlace* will be discussed in 3.5.2 and 3.5.3 respectively.

The main results of Experiment 1 are basically in line with the four predictions deduced from our theoretical framework above. In what follows, we will discuss whether and how the four predictions are supported. These discussions inform the understanding of how adapted structure and imported structure are represented and activated in the mind of a borrower. On the basis of these discussions, we will argue that adapted structure and imported structure carry particular social messages. Finally, we will point out a methodological issue in Experiment 1.

3.5.1 Topic effect

It was predicted that, speaking about Māori activates the social concept "Māori" and a representation of imported structure, the result of which is that imported structure is more likely to be produced [Prediction 2]. Our result shows a robust topic effect on the likelihood of adaptation vs. importation, and the direction was as predicted. Although topic effects have been reported in literature on sociolinguistic variation, such as style shifts and dialect shifts, they were yet to be explored with regards to loanword phonology. This study has extended the effects to the domain of loanword phonology, which has rarely been discussed in relation to sociolinguistic factors.

As for topic effects, there are two significant interaction effects. One interaction is with *session*. This interaction indicates that topic effects are more robust earlier in the experiment in comparison to later in the experiment. This finding seems to be in line with Exemplar Theory. The exemplar-based account is as follows. The representations of the social concept "Māori" and imported structure are not especially activated at the beginning of the experiment, that is, the likelihood of activating adapted structure and imported structure depends on the potential strength of each structure at this stage. As is assumed in Exemplar Theory, the potential strength is a function of the frequency of each structure, and the strength of each structure may differ in accordance with speakers and loanwords. As the experiment proceeds, participants have opportunities to read Māori passages, which further raise the activation of the social concept "Māori." Once the social concept is activated further, the extra-activation continues to some extent, and imported structure is more likely to be activated in general via the socio-indexical link between imported structure and the social concept "Māori." Consequently, topic effects become less robust in the second half, as the social concept is already activated to the point of saturation and less likely to be activated further by a Māori topic in speech. This exemplar-based account may be supported by the fact that the importation rate is in general higher in the second half of the experiment in comparison with in the first half (see Figure 3.9). It could be speculated that the extra-activation of the social concept "Māori" in the first half of the experiment continues, and thus imported structure is more likely to be produced during the second half of the experiment.

The other significant interaction is that with *firstTopic*. Recall that some participants began with Māori passages whereas the other participants began with neutral passages. This interaction suggests that only speakers beginning with neutral passages changed their importation rates in accordance with topics of reading passages. This finding can also be captured as with the interaction of *topic* and *session*. When speakers begin with Māori passages, the social concept "Māori" receives further activation at the very beginning of the experiment. The extra-activation may continue throughout the rest of the experiment, and the topic alternation does not affect the activation of the social category and imported structure anymore. On the other hand, when speakers begin with neutral passages, the representation of the social category "Māori" is not especially activated at the beginning of the experiment. That is, the likelihood of adaptation vs. importation purely depends on the potential strength of adapted structure and imported structure at the initial stage of the experiment. Once passages shift to those about Māori, the representation of the social concept "Māori" starts to be further activated, and imported structure becomes more likely to be initiated via the socio-indexical link, that is, imported structure becomes more likely to be chosen in production. This is why topic effects are robust for speakers beginning with neutral passages. This exemplar-based account may be supported by the fact that participants beginning with Māori passages are more likely to produce imported structure in general (see Figure 3.10).

Finally, we would like to point out another theoretical interpretation. Although our theoretical framework is established based on Exemplar Theory, topic effects observed in our experiment can be captured by audience design framework (Bell 1984; 2001; 2016). This framework assumes that speakers attune their speech to that of audience members in order to express their association with the members. This audience-oriented usage of linguistic variants is called "audience design." Bell claims that speakers may adjust their speech not only to audience members but also with regards to non-audience (e.g., topics and settings). Bell (1984: 181) notes "speakers associate classes of topics or settings with classes of persons. They therefore shift style when talking on those topics or in those settings as if they were talking to addressees whom they associate with the topic or setting. […] The basis of all style shift according to nonpersonal factors lies then in audience-design shift." In our case, when speakers talk about Māori, they may accommodate to Māori people or those strongly associated with Māori, and they may be more likely to produce imported structure, which is employed in Māori speech. Note that this audience-design account and our exemplar-based account do not exclude each other. Rather, the audience-design account can be implemented within the exemplar-based account. That is, passages about Māori may activate exemplars produced by Māori people and/or those strongly associated with Māori, which may include more imported structure, and consequently imported structure is more likely to be chosen.

3.5.2 Speakers' association with source language and culture

We deduced two predictions about speakers' association with Māori: [Prediction 4a] if a

NZE speaker has stronger relationship with Māori (i.e., the source language and its culture), the speaker may be exposed to imported structure and store more exemplars with imported structure, the result of which is that the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ]; [Prediction 4b] if a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori," and consequently the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ]. As discussed below, Prediction 4a is strongly supported in our data set, and Prediction 4b is weakly supported.

Strictly speaking, Prediction 4a (relationship with Māori) is not supported statistically. We explored two variables related to this prediction: *PC-culture* (relationship with Māori culture and language and individual proficiency in Māori) and *PC-people* (relationship with Māori people and neighbourhood proficiency in Māori). *PC-people* is not significant at all (p=0.31), despite the fact that some previous literature show that the importation rates are affected by the relationship with the source language speakers (Poplack et al. 1988; Lev-Ari et al. 2014). The reason why the current study does not find this significant effect may be because most participants in the current study have a very weak relationship with Māori people and speakers. The answers to the questions about Māori people and speakers (Section C of questionnaires) show that the participants have almost no Māori friends and know almost no Māori speakers (i.e., means and medians are about 5% or less for all the questions in Section C). The participants in the current study might not be suitable to test this variable. Although *PC-culture* does not achieve a significant level, it does trend in the predicted direction (p=0.08). This suggests that there is a slight tendency that speakers strongly related with Māori culture and language are more likely to produce imported structure. This finding is in line with Prediction 4a. That is, speakers strongly related to Māori culture and language are more likely to be exposed to the use of imported structure. Consequently, the potential strength of the representation of imported structure becomes higher in the cognitive systems of those speakers, and the imported structure is more likely to be activated and selected in production of loanwords. What is interesting is that our result suggests that speakers could store a higher number of exemplars with imported structure, if they have strong affiliation with Māori cultural events or places, and Māori media even without a strong relationship with Māori people and speakers.

On the other hand, Prediction 4b (attitudes towards Māori) is statistically well-supported. It was found that the effect of *PC-attitude* is highly significant. As *PC-attitude* means "attitude towards Māori culture and language," this finding suggests that speakers with more positive attitudes towards Māori culture and language are more likely to produce imported structure. The effect of this attitude can be captured by exemplar-based approaches as in Prediction 4b, that is, speakers with more positive attitudes towards Māori may potentially activate a social concept "Māori." As a result, imported structure is also activated because it is cognitively linked with the social concept, and it is more likely to be produced. To the best of our knowledge, this study is the first to show that importation rates are affected by attitudes towards the source

language and the culture.

Finally, the effect of *speakerPlace* is worth commenting on. It is not significant, but it shows a trend (p=0.07). More specifically, this variable indicates that North Islanders are more likely to produce imported structure than South Islanders. This is unsurprising from the point of exemplar view, because there are more Māori people living in the North Island and North Islanders may have more opportunities to store exemplars with imported structure. This effect can be encapsulated in the same way as *PC-culture* [Prediction 4a]. As this variable was not well-balanced in the current study (i.e., 11 participants come from the North Island whereas 21 participants come from the South Island), it might be worth exploring this variable in more detail in future work.

3.5.3 Words' association with source language and culture

It was predicted that words strongly associated with Māori are more likely to be produced with imported structure, as they are used more frequently within the Māori community and more likely to be stored with imported structure [Prediction 5]. This effect is nuanced in our dataset. Although words' association with Māori (*wordMaoriness*) was significant without by-speaker random slopes for this variable (p<0.001), it was not found to be significant (p=0.11) after adding the random slopes to the statistical model. Note that the direction is as predicted. One possible reason is that target loanwords employed in this experiment are all place names and the number of types is small. That is, the narrow set of loanwords employed in this experiment may not allow us to explore a variety of degrees of words' association with Māori, and thus this variable did not achieve a sufficiently significant effect. As will reported in the next chapter, Experiment 2 examines a wider set of loanwords including common nouns, and the result shows that words' association with Māori is a significant predictor.

Another variable *wordPlace* trends in our dataset (p=0.07). This variable suggests that there is a tendency that place names referring to places in the North Island are more likely to be produced with imported structure. Although this effect is tentative, it could be given the same account as Prediction 5. That is, place names in the North Island are more likely to be produced in Māori community, because there are more Māori people living in the North Island, and consequently North Island place names are more likely to be stored with imported structure.

In this way, although the effects of the two word-specific associations with the source language are tentative, their directions are consistent with Prediction 5. The variable of interest *wordMaoriness* will be explored in the next chapter using a larger set of Māori loanwords.

3.5.4 Social messages of imported structure and adapted structure

The concrete research question addressed in this chapter (RQ1a) is whether the variation in loanword phonology depends on sociolinguistic variables and whether it is socially meaningful. Our results suggest that the variation in loanword phonology is socially meaningful. The topic effects indicate that this is a type of intra-speaker variation, because speakers choose

the variants (i.e., imported structure or adapted structure) in accordance with topics in speech. That is, this variation is used to style speech in accordance with speech situations. Furthermore, the significant effects of speakers' attitudes towards Māori provide evidence that this variation is a type of inter-speaker variation. Recall that relationship with Māori shows a statistical trend, and it could also be regarded as evidence that it is a type of inter-speaker variation.

According to Bell (2014), inter-speaker variation itself does not attest to the existence of social messages, but intra-speaker variation does. On the other hand, Eckert (2016) notes that variation is always socially meaningful. In either case, our results suggest that the variants in loanword phonology carry particular social messages. Although the detailed social messages carried by adapted structure and imported structure need to be explored further, we can hypothesize that each variant carries the following social messages on the basis of inter-speaker variation, in which adapted structure is more likely to be used by speakers weakly associated with Māori and imported structure is more likely to be used by speakers strongly associated with Māori:

(4) Social messages carried by adapted structure and imported structure in loanwords

Variation	Variant	Carried messages
/r/	[ɹ]	→ Social message dissociated from Māori
	[ɾ]	→ Social message associated with Māori

Loanword phonology may provide an interesting test case to explore social meaning in linguistic variation. Actually, Hall-Lew et al. (2012) demonstrate that the second vowel of a loanword *Iraq* can be realized as either /æ/ or /a:/, and that this variation is used by politicians to express their social identity. It is worth exploring what kind of social message is, in general, expressed by choosing a variant of loanword pronunciation.

3.5.5 Remaining issue

This chapter has shown that there is a robust effect of topic on the likelihood of adaptation vs. importation, that is, speakers are more likely to produce imported structure when they read Māori passages. However, the experiment reported in this chapter may have a methodological issue. The issue is that the Māori passages include a few non-target loanwords with /r/ (e.g., *Aotearoa*, *Māori*, *marae*, and *Matariki*), whereas neutral passages do not. As will be shown in the next chapter, these non-target loanwords are relatively likely to be produced with imported structure. That is, there is a slight possibility that the representation of imported structure is activated by the pronunciation of [ɾ] sounds in non-target loanwords, and the increasing rate of importation might be attributed to non-target loanwords rather than passage topics. In order to sort out this issue, Experiment 3 was designed in a way that the number of non-target loanwords with /r/ could be controlled via employed passages.

3.6 Summary

Let us now summarize the findings reported in this chapter. This chapter explored the effects of sociolinguistic factors on loanword phonology by running a passage-reading task. More specifically, we explored three types of factors: [RQ2] topic in speech, [RQ4] speakers' association with the source language and community, and [RQ5] words' association with the source language and its culture. First, the topic effect is robust in our result, and it was found that imported structure is more likely to be produced in speech related to the source language and community. This effect indicates that this variation is an intra-speaker variation. Next, speakers' association with the source language also affects the likelihood of adaptation vs. importation to some extent. It was found that the effect of relationship with Māori is not strong in our data set, but that of attitudes towards Māori is robust. This result suggests that this variation is inter-speaker variation. Finally, the effect of words' association with the source language was not found to be significant. It was speculated that the null result might be due to the narrow set of loanwords employed in this experiment. As demonstrated in 3.5, these significant effects can be encapsulated by our theoretical framework (see 1.7). More specifically, they can accurately be predicted well by postulating that exemplars with imported structure are stored closely in relation to a social concept "Māori," and that the strength of imported structure is updated and determined in the daily usage. The theoretical findings in this chapter are discussed in the final chapter, alongside with the findings in the next two chapters.

Although sociolinguistic factors have not often been discussed in relation to loanword phonology in previous literature, these findings reported throughout this chapter suggest that sociolinguistic factors influence the selection of imported structure vs. adapted structure. Namely, it is essential to take social factors into account when discussing loanword phonology, and the variation in loanword adaptation can be socially meaningful. On the basis of the patterns of the variation, we proposed that adapted structure [ɪ] carries a social message dissociated from Māori while imported structure [ɾ] carries a social message associated with Māori. In the next two chapters, we attempt to replicate the effects reported in the current chapter and explore another sociolinguistic factor, namely cultural images.

Chapter 4 Likelihood of adaptation vs. importation II: Effect of cultural images

4.1 Introduction

As with the last chapter, the research question addressed in this chapter is whether the selection of imported structure vs. adapted structure depends on sociolinguistic factors as in other sociolinguistic phenomena such as dialect shifts [RQ1a], and whether it is a socially meaningful variation. In order to address this question, we explored the effect of a topic in speech on the likelihood of adaptation vs. importation in the last chapter. The main aim of this chapter is to explore another sociolinguistic effect, namely that of cultural images. Additionally, we explore speaker-specific properties and word-specific properties:

(1) Research questions addressed in this chapter
RQ3: "Is the likelihood of adaptation vs. importation affected by cultural images?"
RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"
RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

Addressing these questions informs the understanding of how adapted structure and imported structure are represented in the mind of a borrower. As with the previous chapter, we could specifically test the hypotheses about (0) representation of adapted structure and imported structure and (1) category activation in our theoretical framework (see 1.7). Once again, the results will suggest that variation in loanword phonology is socially meaningful.

As will be reviewed below, the effect of cultural images has, in general, hardly been discussed in linguistic literature. To the best of our knowledge, this effect has not been explored in relation to speech production, although it has been discussed in relation to speech perception (Hay & Drager 2010). The current study aims to test whether this effect extends to the production of a linguistic variant in loanword phonology.

This chapter consists of six sections. Section 4.2 reviews some assumptions and hypotheses, and deduces predictions related to the three research questions in (1). In section 4.3, the methodology is outlined, while in section 4.4 the results of the experiment are reported. The results are discussed in section 4.5, and a summary is offered in section 4.6.

4.2 Background

4.2.1 Theoretical framework

First, let us review our theoretical framework. As with the last chapter, the relevant parts

of our theoretical framework are (0) exemplar cloud with categories in memory, (1) category activation, and (2) exemplar selection. The important hypotheses and assumptions are restated as follows:

(2) Relevant hypotheses and assumptions to this chapter

(0a) exemplars including imported structure [ɾ] and adapted structure [ɹ] are both stored in the mind of a NZE speaker, and the phonological categories [ɾ] and [ɹ] are formed and represented in her mind, because both the structures are frequently used in New Zealand English.

(0b) the categories of adapted structure and imported structure are cognitively linked with each other, as they are variants of /r/-sounds in Māori loanwords.

(0c) the imported structure [ɾ] is socially associated closely with the concept "Māori," because imported structure is identical to the structure used in the Māori language and society.

(1a) the likelihood of activation of adapted structure and imported structure potentially depends on the strength of the exemplars belonging to each category (i.e., the imported structure is more likely to be activated, if it is used more frequently and/or recently, with the reverse true for the adapted structure).

(1b) the activation of imported structure is more likely to occur when the concept "Māori" is activated, as we hypothesized above that (0c) imported structure is closely associated with the social concept "Māori."

(1c) the social concept "Māori" may be activated by speech situations such as a topic in speech and a presented cultural image.

(1d) speakers may activate the social concept "Māori" when they have more positive attitudes towards Māori.

(2a) an exemplar is chosen in accordance with the category (i.e., adapted structure or imported structure) selected in the category activation, i.e., an exemplar belonging to a phonological category [ɹ] is chosen when the category [ɹ] is activated, whereas an exemplar belonging to a phonological category [ɾ] is chosen when the category [ɾ] is activated.

(2b) an exemplar with higher strength is more likely to be chosen for the production.

4.2.2 Predictions

The aim of this sub-section is to review previous studies relevant to the above research questions, and deduce the predictions on the basis of our theoretical framework.

4.2.2.1 Cultural image effect

Scarce work has been done on the effect of cultural images on linguistic processing in general. To the best of our knowledge, this effect has been discussed only by Hay & Drager (2010) in relation to speech perception. They ran a unique experiment to test this effect. At the

beginning of their experiment, NZE speakers were exposed to either a kiwi bird stuffed toy or a kangaroo stuffed toy. It is assumed that a kiwi bird is culturally associated with New Zealand, whereas a kangaroo is associated with Australia, because each animal is native to New Zealand and to Australia respectively. After exposure to one of the stuffed toys, the participants completed a forced-choice task. They listened to a sentence with a target word, while seeing a sentence on an answer sheet in which a target word is underlined. They then listened to continua of synthesized vowels, and were asked to match which synthesized vowel is close to the vowel heard in the target word within the sentence. The continua of the synthesized vowels are divided into 6 steps, and range from Australian-like vowels to New Zealand-like vowels. They matched vowels in 50 sentences throughout the experiment. Their major finding is that female speakers exposed to a kangaroo stuffed toy are more likely to choose an Australian-like synthesized vowel, when they match a synthesized vowel to a vowel in a target word, with the reverse true for female speakers exposed to a kiwi bird stuffed toy. In other words, the NZE speakers shifted their perception towards vocalic variants of a dialect in accordance with a stuffed toy to which they are exposed at the beginning of the experiment.

This cultural image effect on speech perception can be neatly captured by exemplar-based approaches (Hay & Drager 2010). They argue that the exposure to a stuffed toy may be akin to the exposure to a concept of a dialectal region. That is, the exposure to a kiwi bird stuffed toy may raise the activation of the concept "New Zealand," and the exposure to a kangaroo stuffed toy may raise the activation of the concept "Australia."[7] As is hypothesized throughout the current thesis, the activation of a social category may raise the activation of a relevant linguistic category and exemplars. That is, the activation of the social concept "New Zealand" may activate the linguistic category represented by exemplars produced by New Zealanders, and the activation of the social concept "Australia" may activate the linguistic category formed by exemplars produced by Australians. As Pierrehumbert (2001) notes that a label with more activated exemplars has an advantage in the competition, perception is biased towards a class of activated exemplars. Consequently, exemplars stored from New Zealanders are more likely to be chosen in perception when a social concept "New Zealand" is activated, and exemplars stored from Australians are more likely to be perceived when a social concept "Australia" is activated.

In the same way, it can be expected that cultural images may affect the production of a linguistic variant. That is, we could expect that a cultural image may activate the relevant concept, and exemplars associated with the concept may be more likely to be activated and chosen in production. In the case of NZE loanword phonology, we hypothesized that (1c)

[7] The association between a visual expression and a social concept is also discussed by MacFarlane & Stuart-Smith (2012). They demonstrated that Scottish speakers can match a particular linguistic variant in Glasgow English to a speaker with certain social properties (i.e., Glaswegian vs. Glasgow Uni), which are expressed by brand pictures (e.g., Adidas vs. Gant) in their experiment.

exposure to a Māori cultural image may raise the activation of a social concept "Māori." Our theoretical framework specifically hypothesized that (1b) the activation of imported structure may occur more frequently when the concept "Māori" is activated because (0c) the imported structure [ɾ] is socially associated closely with the concept "Māori." Finally, it is assumed that (2a) an exemplar is chosen in accordance with the category selected during the category activation. On the basis of these hypotheses, we can deduce the following prediction that relates to RQ3:

Prediction 3: When a NZE speaker sees a cultural image related to Māori when speaking, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

4.2.2.2 Speakers' association with Māori

As was tested in the last chapter, the selection of adapted structure vs. imported structure is expected to be affected by speakers' experience in daily conversation. More specifically, speakers strongly related with Māori may have more opportunities to hear imported structure, which is frequently used in a Māori community, and consequently they may use imported structure more often (see 3.2.2.2):

Prediction 4a: If a NZE speaker has a stronger relationship with Māori (i.e., the source language and its culture), the speaker may be exposed to more imported structure and store more exemplars with imported structure, with the result that the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

In addition, we hypothesized that speakers may potentially activate a social concept when they have positive attitudes towards the Māori community. As the activation of a social concept may raise the activation of the relevant linguistic category via the socio-indexical link, we can deduce the following prediction, and with more detail in 3.2.2.2:

Prediction 4b: If a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori," and consequently the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

4.2.2.3 Words' association with Māori

As was deduced in the last chapter, the likelihood of adaptation vs. importation may also be affected by the history of word usage. In particular, loanwords strongly associated with Māori may be heard with imported structure more often, and consequently they may be more likely to be produced with imported structure (see 3.2.2.3):

Prediction 5: If a loanword is more strongly associated with Māori (i.e., the source language and its culture), the loanword may more often be stored with imported structure, the result of which is that the loanword is more likely to be produced with imported structure [ɾ] than adapted structure [ɹ].

4.3 Methodology

This section illustrates the research design employed in the current chapter. A word-list reading task (Experiment 2) was run in order to test the above predictions. In this task, participants read aloud Māori loanwords and some native words within a carrier sentence while seeing a cultural image.

4.3.1 Participants

32 NZE speakers participated in this task. As was noted in the last chapter, they also took part in Experiment 1, before they participated in this experiment. After this word-list reading task, they filled in questionnaires.

4.3.2 Experiment 2: material and procedures[8]

The following target loanwords were employed in this task. The target loanwords include word-initial and/or word-medial /r/, of which realizations can be classified into adapted structure [ɹ] or imported structure [ɾ] (see 1.6.3):

(3) 36 target loanwords in word-list reading task[9]
Akaroa, Aoraki, Aotearoa, Haere mai, harakeke, Kaikoura, , kakariki, kauri, Kia ora, koru, kumara, Maori, Maruia, Matariki, marae, Moeraki, Oamaru, Paeroa, Porirua, Rangi, Rangiora, Rangitoto, Rotorua, rata, rimu, tarakihi, Taranaki, Tauranga, te reo, Timaru, Tokoroa, tuatara, Waimairi, Waimakariri, Wairoa, Whangarei

Four of the target loanwords include two /r/ sounds (*Porirua*, *Rangiora*, *Rotorua*, and *Waimakariri*), and they are annotated separately. Hence, 40 realizations of /r/ can be collected from this set of loanwords.

The following native words and loanwords in (4) were also used as references or fillers. First, 6 words include LOT vowels, 6 words include THOUGHT vowels, 6 words include GOAT vowels, and 8 loanwords ending with /ɔ/. The reason of choosing these words is that we originally planned to explore the realizations of /ɔ#/ and classify them into THOUGHT, GOAT, or LOT vowels. As we acoustically analysed the data, it was found that the realization of /ɔ#/ is not as categorical as we expected. Hence, the realization of /ɔ#/ is not statistically analysed in the current study, but it was discussed qualitatively in 1.6.3. Next, 6 words include initial

[8] This experiment was pre-registered along with Experiment 1 as #5095 using AsPredicted (https://aspredicted.org/index.php).

[9] These loanwords were presented without macrons on the computer screen. The reason is that texts with macrons did not work well in our experimental program. We believe that the orthography without macrons did not affect speakers, because orthography without macrons is still more common in written texts such as newspapers or websites (Sigley 2018), and an experiment shows that the presence of a macron does not affect phonotactic knowledge of a NZE speaker (Oh et al. 2018).

approximants, 6 words include medial approximants and 4 words include medial coronal plosives. These words were used as references to classify the realizations of /r/. The other 32 words are related to New Zealand. 14 words are New Zealand place names, and 18 words are related to kiwi culture and lives. These words are included to disguise the aim of the experiment:

(4) 74 filler words in word-list reading task
[LOT] tea pot, bus stop, sea fog, sheep dog, livestock, robot
[THOUGHT] seesaw, chainsaw, jigsaw, bear paw, cat paw, dog paw
[GOAT] photo, gecko, echo, motto, tomato, potato
[loanwords with /ɔ#/] kakapo**,** katipo, moko, pukeko, Taupo, Tekapo, Waikato, Waitomo
[#r] result, receiver, robust, radio, rugby, restaurant
[VrV] mirror, parrot, sparrow, arise, eraser, director
[VtV] butter, city, matter, party
[NZ place names] Ashburton, Auckland, Blenheim, Christchurch, Dunedin, Gisborne, Greymouth, Invercargill, Milford Sound, Nelson, Palmerston North, Queenstown, Stewart Island, Wellington
[NZ English themed words] All Blacks, Beehive, bell bird, dairy, fantail, fern, feijoa, fish and chips, gumboot, hokey pokey, Marmite, New World, oyster catcher, pavlova, penguin, pikelet, Sky Tower, Tip Top

Each participant was asked to pronounce these words within a carrier sentence "Say _ please" while seeing a cultural frame. The stimuli were presented using *E-prime 2.0 software* (Psychology Software Tools, Pittsburgh, PA). At the start of each trial, a word written in English orthography appeared within a carrier sentence on the screen of a computer and remained there for the rest of the trial. After the participants pronounced the word within a carrier sentence, they pressed the space bar and the next word appeared on the screen. They repeated this procedure until they pronounced all the words. After they finished the task, they retook the same task again, that is, each speaker took the same task twice. Hence, 2,560 tokens (32 participants x 40 /r/ tokens x 2 times) are supposed to be collected throughout this experiment.

In order to test the effect of cultural images on the likelihood of adaptation vs. importation, the cultural frames were manipulated on the screen. Every time a participant pressed the space bar, a cultural frame alternated along with the word. The frames in Figure 4.1 were employed. The left-hand one is supposed to be strongly associated with Māori because it includes Māori cultural expression, koru, and the right-hand frame is not associated with Māori because they look like western photo frames. When this experiment was designed, some New Zealanders were asked whether the left-hand frame looks Māori-like. All the New Zealanders said that they definitely look Māori-like. Hereafter, the former types of cultural frames are called "Māori cultural frames," and the latter types of frames are called "neutral cultural frames." Note that both the types of cultural frames were coloured in four ways: red, black, light-brown, and dark-

brown (see Appendix E for a complete set of cultural images):

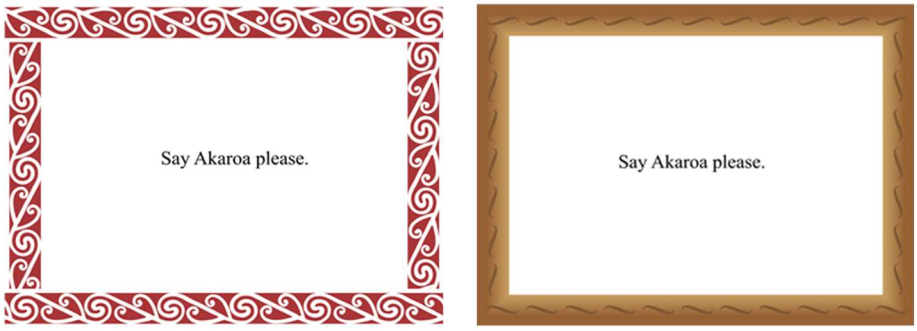


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Figure 4.1 Cultural frames: Māori cultural frame vs. neutral cultural frame

The order of the words and the frames was pseudo-randomized using R (R Core Team 2016) in the following way. First, the loanwords were assembled into two sets, Set A and Set B. In one task, Set A loanwords appeared within Māori cultural frames and Set B loanwords appeared within neutral cultural frames. In the other task, Set A loanwords appeared within neutral cultural frames and Set B loanwords appeared within Māori cultural frames. The order was counter-balanced, that is, half the participants (Participants A) pronounced Set A loanwords within Māori cultural frames first, while the other half (Participants B) pronounced Set B loanwords within Māori cultural frames first. The other native words appeared within either Māori cultural frames or neutral cultural frames in a random way. It was ensured that the same cultural frames were not consecutively presented, the first cultural frame was always neutral, and the first word was always a native word:

	Participants A (P1, P3, P5…)	Participants B (P2, P4, P6…)
1st Task	Loanwords A / Māori frame Loanwords B / Neutral frame	Loanwords A / Neutral frame Loanwords B / Māori frame
2nd Task	Loanwords A / Neutral frame Loanwords B / Māori frame	Loanwords A / Māori frame Loanwords B / Neutral frame

Table 4.1 Procedure in Experiment 2

After this experiment, the participants filled in questionnaires about speaker-specific properties and word-specific properties.

4.3.3 Questionnaires

4.3.3.1 Speakers' association with Māori

As was explained in Chapter 2, PCA was performed on their answers of questionnaires

about their association with Māori. The 27 variables in the questionnaires were unified into the following three principal components:

(5) Meanings of three principal components
PC-attitude: attitude towards Māori culture and language
PC-culture: relationship with Māori culture and language, and individual proficiency
PC-people: relationship with Māori people, and neighbourhood proficiency

4.3.3.2 Words' association with Māori and word frequency

As was explained in Chapter 2, participants were asked to rate words' association with Māori and word frequency in questionnaires. As with the last chapter, both the raw values were z-scored within each participant, because the ranges of raw values vary in accordance with each participant (see 2.3.3). The peanut plots in Figures 4.2 and 4.3 show the distribution of z-scored values of words' association with Māori and word frequency, and the inside dots indicate the means across speakers. For example, many participants feel that *te reo* and *marae* are strongly associated with the Māori society and culture, whereas *Akaroa* and *Timaru* are weakly associated with Māori. The reason may be that the meanings of *te reo* and *marae* are related to Māori culture, while *Akaroa* and *Timaru* are place names. As for word frequency (Figure 4.3), *kumara* and *Maori* are rated as frequent in daily usage, whereas *harakeke* and *Maruia* are rated as infrequent.

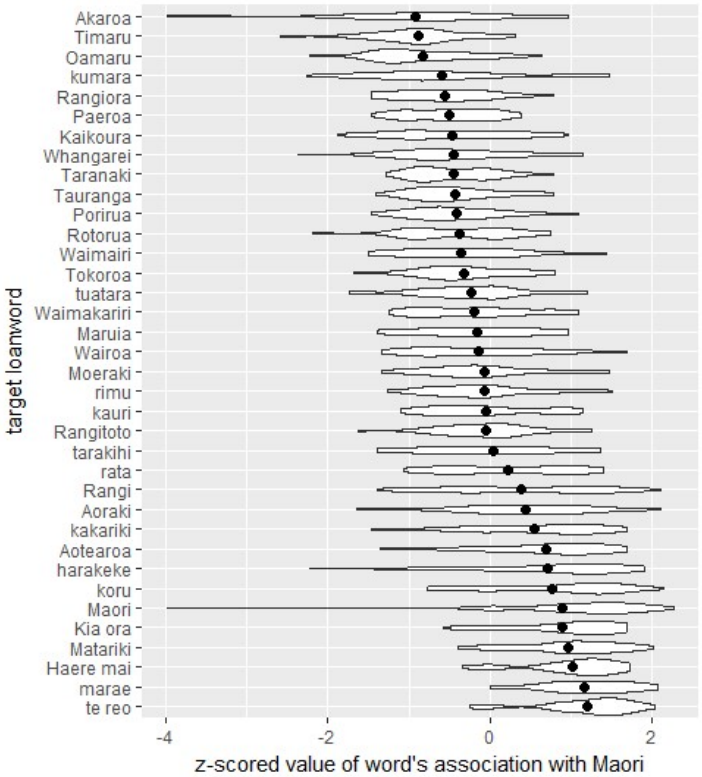

Figure 4.2 Peanut plot for z-scored words' association with Māori

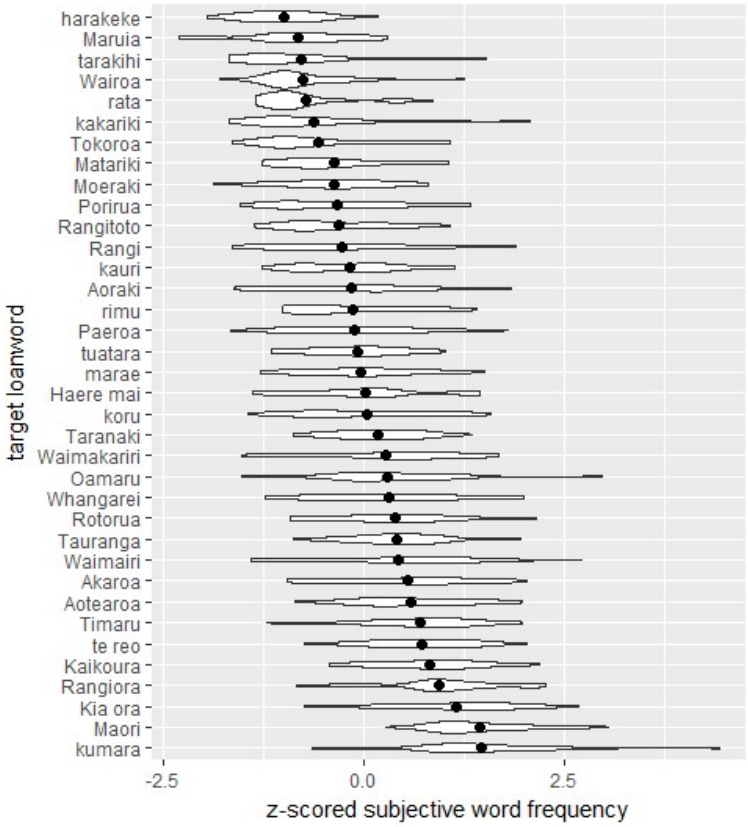

Figure 4.3 Peanut plot for z-scored subjective word frequency

Note that words' association with Māori and word frequency do not correlate at all, as Pearson's correlation values are r=−0.09.

4.3.4 Acoustic analyses

As was explained in the last section, the classification of /r/ into adapted structure and imported structure mainly relies on the acoustic visualization using Praat (Boersma & Weenink 2016). More specifically, if voiced sounds have clear consonantal edges, then they were classified as imported structure [ɾ]. If they have no clear consonantal edges with lowered F3, they were classified as adapted structure [ɹ]. The other realizations were impressionistically classified into adapted structure, imported structure, or others (see 3.3.4 for the detail). The impressionistically classified tokens are less than 10%, as will be stated in the next section.

4.4 Results

In this section, we will illustrate the results of the experiment, and discuss the statistical analyses.

4.4.1 Number of observations

2,560 tokens of /r/ were supposed to be collected. 59 tokens were excluded because of mispronunciation or disfluency. 134 tokens were removed, because participants did not know

some loanwords (subjectively rated as 0 with regards to the participants' word use). Finally, the following tokens remained.

Annotation	Number
Acoustically identified tap [ɾ]	1,372 (57.9%)
Acoustically identified approximant [ɹ]	774 (32.7%)
Impressionistically identified tap [ɾ]	116 (4.9%)
Impressionistically identified approximant [ɹ]	50 (2.2%)
Impressionistically deleted sounds (or others)	55 (2.3%)
SUM	2,367

Table 4.2 Total number of observation

4.4.2 Variables

4.4.2.1 Response variable: adaptation vs. importation

As with the previous chapter, the response variable is a binary variable: adapted structure [ɹ] vs. imported structure [ɾ]. Impressionistically deleted sounds are excluded from our statistical analysis, and acoustically identified tokens and impressionistically identified tokens were collapsed into a single class, because logistic regression analyses can only handle a binary variable. Consequently, 1,488 tokens with imported structure (64.3%) and 824 tokens with adapted structure (35.7%) are statistically analysed.

4.4.2.2 Key predictors: cultural images and association with Māori

The variable of most interest is *frame* (Māori cultural image vs. neutral cultural image). As stated above, the experiments were designed to make sure that participants read aloud loanwords while seeing either a Māori cultural frame or a neutral cultural frame. The tokens produced while seeing a Māori frame were coded as Māori and those produced while seeing a neutral frame were coded as neutral.

As with the last chapter, the speakers' association with Māori is also examined. As was explained above, their association can be captured by three principal components: *PC-attitude* (attitude towards Māori culture and language), *PC-culture* (relationship with Māori culture and language and individual proficiency in te reo Māori), and *PC-people* (relationship with Māori people and neighbourhood proficiency in Māori). These variables are numeric.

Finally, words' association with Māori is also an important predictor. As was explained above in Figure 4.2, participants were asked to answer how strongly each target loanword is associated with Māori, and the rated values were z-scored within each speaker. The z-scored values will be fitted in the following statistical analyses. This variable is treated as *wordMaoriness* in our data frame.

4.4.2.3 Control variables

In addition to the five key variables, some control variables are also examined. As in the last chapter, word frequency (*subjFreq*) is examined, because some previous studies point out that high frequency words are more likely to undergo adaptation (Poplack & Sankoff 1984; Friesner 2009; 2010). As was stated above, word frequency was subjectively rated by each participant, and it was z-scored within each participant.

As was discussed in the last chapter, *speakerPlace* (a participant comes from North Island vs. South Island) is also examined. This variable showed a trend in Experiment 1, and it is explored again. As for *wordPlace*, it is not explored in this chapter, because many target loanwords are not place names. Instead, *wordType* (common noun vs. proper noun) is examined as a word-specific control variable.

As participants completed this word-list reading task twice, we explore *session* (first session vs. second session) as in the last chapter. The last chapter demonstrates that speakers become more likely to produce imported structure later in the experiment. Hence, it can be expected that participants may produce more imported structure later in the experiment.

We also examine some variables that may affect the duration of imported structure: *position* (word-initial vs. word-medial), *speechRate* (syllables per second), *NofSeg* (number of segments), *precSt* (preceding vowel is main-stressed or not), and *folSt* (following vowel is main-stressed or not). These variables were included as predictors of duration in our data frame, although they are not expected to affect the likelihood of adaptation vs. importation. The duration will be discussed in Chapter 6. Table 4.3 shows a list of variables examined in the following statistical analysis.

frame	Current presented cultural frame is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
subjFreq	Subjective word frequency (numeric)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
wordType	Loanword is common noun vs. proper noun (binary)
session	Pronounced in the first session (before a break) vs. the second (binary)
position	/r/ sound is word-initial vs. word-medial (binary)
speechRate	Syllables per second (numeric)
NofSeg	Number of segments within a target loanword (numeric)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)

Table 4.3 List of variables examined in statistical analysis

4.4.3 Logistic regression analyses

The 2,312 tokens of /r/-sounds were hand-fitted into a mixed-effects logistic regression model with bobyqa optimizer using the *glmer* function in the *lme4* library (Bates et al. 2015) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 6 variables (*subjFreq*, *wordType*, *speechRate*, *NofSeg*, *precSt*, and *folSt*) were eliminated one-by-one through pairwise comparisons of models with and without each variable. As for these 6 variables, their interactions with the other variables were not examined, because the model including their interactions did not converge well and their p-values were very high. Then, backward elimination was run manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the remaining 8 variables (*frame*, *PC-attitude*, *PC-culture*, *PC-people*, *wordMaoriness*, *speakerPlace*, *session*, and *position*). The elimination was based on p-value, that is, either a single effect or an interaction with the highest p-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was adopted. Through this process, the three factors (*frame, PC-culture,* and *PC-people*) were also removed. Finally, by-word random slopes for *PC-attitude, speakerPlace,* and *session*, and by-speaker random slopes for *position* and *wordMaoriness* were added to the model, the result of which is that *position* was removed from the model, as its p-value becomes higher than the threshold of .05. The best-fitted model is shown in Table 4.4. A Variance Inflation Factor (VIF) test was performed on the model, and all VIF scores were below 4, which suggests that the model has no multicollinearity problem. Note that the reference levels for the following summary is `sPeakerPlace North` and `session First`:

adap/imp~PC-attitude+wordMaoriness+speakerPlace+session+PC-attitude:session[10]

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	3.7243	0.9606	3.877	0.000106	***
PC-attitude	1.6865	0.4535	3.719	0.000200	***
wordMaoriness	0.2568	0.1281	2.004	0.045024	*
speakerPlace South	-3.4659	1.1668	-2.970	0.002974	**
session Second	0.2939	0.1715	1.714	0.086542	.
session Second:PC-attitude	-0.2570	0.1265	-2.031	0.042236	*

Table 4.4 Best-fitted model as result of backward elimination

[10] As with Chapter 3, we explored a subset including only acoustically identified tokens. The significance of these variables is basically identical, even when impressionistically identified tokens are removed from the dataset.

Note that the response variable (adapted structure [ɹ] vs. imported structure [ɾ]) is dummy-coded (i.e., 0 is given to the adapted structure [ɹ] and 1 is given to the imported structure [ɾ]) in the above model. That is, positive slopes indicate higher likelihood of importation, whereas negative slopes indicate higher likelihood of adaptation. Let us discuss key variables first. *PC-attitude* and *wordMaoriness* shows significant effects in the predicted direction. The coefficient of *PC-attitude* is positive (β=1.68, z=3.71, p<0.001), and it suggests that NZE speakers with positive attitudes towards Māori culture and language are more likely to import non-native structure. The coefficient of *wordMaoriness* is also positive (β=0.25, z=0.12, p<0.05). This suggests that loanwords strongly associated with Māori are more likely to be produced with imported structure. The interaction between *PC-attitude* and *session* is significant, and it was found that the effect of *PC-attitude* is slightly weaker in the second session, as shown in Figure 4.4. The subsets of data including tokens produced in the first session and in the second session were explored. It was found that the effect of *PC-attitude* is significant in both the first session (β=1.55, z=3.23, p<0.01) and the second session (β=1.34, z=2.85, p<0.01):

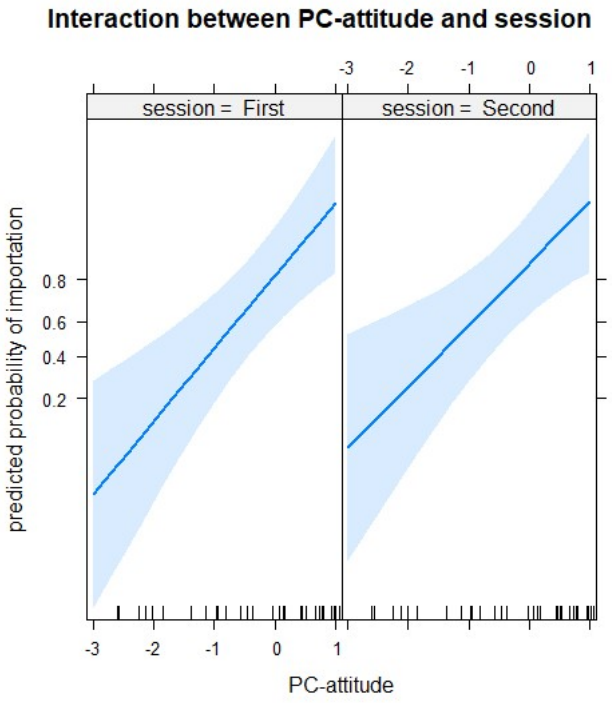

Figure 4.4 Interaction between PC-attitude and session

As for the other three key variables, they do not show significant effects in our data set: *frame* (p=0.09), *PC-culture* (p=0.52), and *PC-people* (p=0.81). Note that *frame* does trend in the predicted direction, that is, imported structure is slightly more likely to be produced when Māori cultural images are presented on screen. This is illustrated in Figure 4.5. The importation probability is 2.2% higher given a Māori frame (65.4%) than given a neutral frame (63.2%):

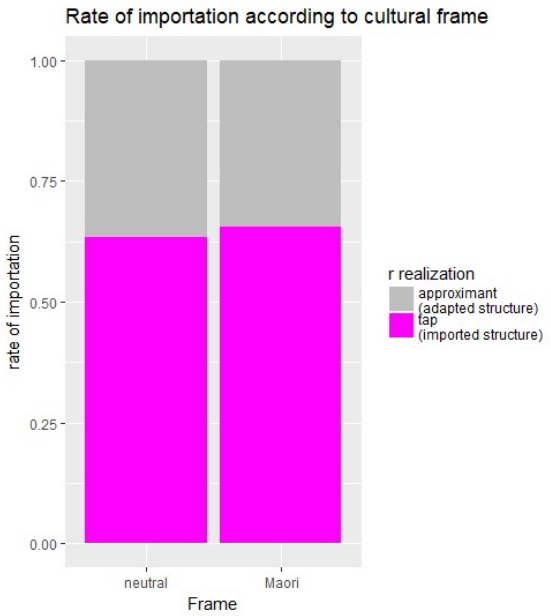

Figure 4.5 Rate of importation according to presented cultural frame

As for control variables, most variables are not significant, and they were removed through pair-wise comparisons.[11] Only *speakerPlace* shows a significant effect (β=−3.46, z=−2.97, p<0.01), and it was found that South Islanders are more likely to use adapted structure than North Islanders. Note that *session* shows a trend, and it was found that imported structure is more likely to be produced at the second session (β=0.29, z=1.71, p=0.08).

As a whole, the variables showing significant effects and a definable trend can be summarized in the following way. Variables showing trend are shadowed in the following table:

frame	Speakers are more likely to produce imported structure while seeing Māori cultural images (p=0.09).
PC-attitude	Speakers with positive attitudes towards Māori are more likely to produce imported structure (p<0.001). This effect is more robust at the first session (p<0.05).
wordMaoriness	Loanwords strongly associated with Māori are more likely to be produced with imported structure (p<0.05).
speakerPlace	North Islanders are more likely to produce imported structure (p<0.01).
session	Imported structure is more likely to be produced at the second session than at the first session (p=0.08).

Table 4.5 Summary of finding in Experiment 2

[11] One of the examines suggested that it is worth exploring whether core loanwords and cultural loanwords behave differently in relation to the likelihood of adaptation vs. importation (see 2.3.2). I added this binary variable to the best-fitted model as a follow-up analysis. It was found to show a trend (p=0.09), which suggests that core loanwords are more likely to be produced with imported structure.

4.5 Discussion

This section will discuss the statistical results in relation to the hypotheses presented in 4.2. In general, it was found that young NZE speakers produce imported structure at a very high rate. In the word-list reading task (Experiment 2) reported throughout the current chapter, 1,488 tokens (64.3%) were produced with imported structure, and 824 tokens (35.7%) were produced with adapted structure. Figure 4.6 illustrates the importation rate per speaker. Recall that the participants in Experiment 2 also took part in Experiment 1 (the passage-reading task). The bars indicate the rate of imported structure in the word-list reading task, while the dots represent the rate of imported structure in the passage-reading task reported in the last chapter.

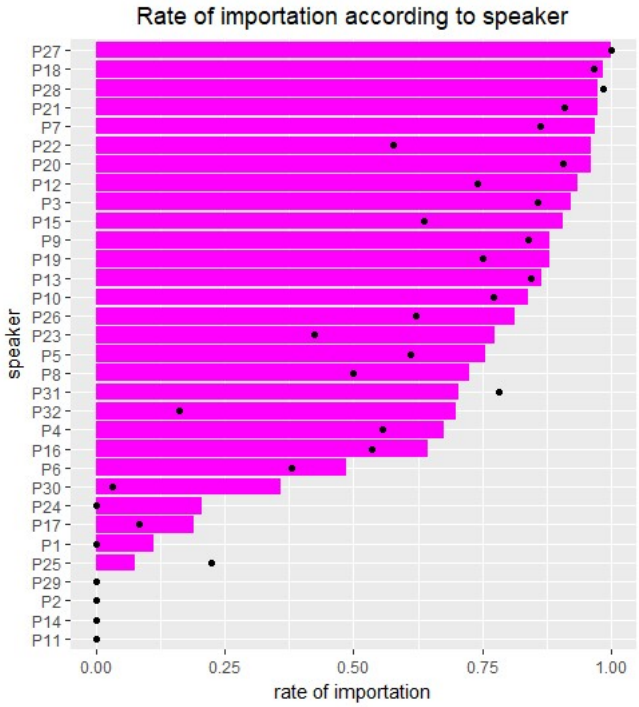

Figure 4.6 Importation rate according to a speaker (bar indicates the rate in word-list reading task and point indicates the rate in passage-reading task)

The importation rate is higher in this word-list reading task than in the passage-reading task, as the edges of most of the bars are further to the right than the dots in Figure 4.6. The reason may be three-fold. First, it is known that a word is pronounced more carefully in a word-list reading task than in a passage-reading task (Labov 1972). As young NZE speakers tend to try to conform to the original Māori pronunciation (Hay et al. 2007), the participants might employ more imported structure in the careful manner of speech. Second, it might be because this task was completed after the passage-reading task (Experiment 1). As was discussed in the last chapter, the representations of a social category "Māori" and imported structure are activated by a Māori topic, and the activation seems to continue to some extent throughout the task. It is unsurprising that this activation still lasts even after the passage-reading task, and imported structure is more likely to be produced in this task. Finally, it may be because the word set is

larger in this task than in the last task. As was seen in the above peanut plot (Figure 4.2), many words strongly associated with Māori (e.g., *te reo*, *marae*, *Haere mai*, and *Matariki*) are those employed only in this word-list reading task. Due to their strong word association with Māori, the importation rate might be inflated in this task.

Let us discuss the control variables. As with Experiment 1, neither phonological variables nor perceived word frequency show significant effects on the likelihood of adaptation vs. importation (see the discussion in 3.5). Once again, *session* was found to affect the likelihood of importation vs. adaptation, that is, loanwords are slightly more likely to be produced with imported structure in the second session. This could be captured by positing that a social concept "Māori" is activated by the production of a larger number of Māori loanwords, and consequently imported structure becomes more likely to be induced via the socio-indexical link (see 4.5.3). Our result suggests that the importation rate is not affected by word type (i.e., common noun and proper noun), as the effect of *wordType* is not statistically significant. This might imply that common nouns and proper nouns are borrowed and pronounced in a similar manner at least by young NZE speakers. It was also uncovered that non-native rhotic sounds can be imported equally both in word-initial position and in word-medial position, as *position* is not a significant predictor. Our dataset suggests that this non-native rhotic sound can be pronounced regardless of the position, and this sound is different from a flap sound or a voiced /t/, which is a word-medial allophone of /t/ in the native phonology (see 1.6.3). Another control variable *speakerPlace* will be discussed in 4.5.2 alongside with other speaker-specific properties.

In what follows, we will discuss the results relevant to the four predictions in 4.2. The discussions develop the understanding of how adapted structure and imported structure are represented in the mind of a borrower. By discussing the results reported in the current chapter, we could test the hypotheses about (0) representation of adapted structure and imported structure and (1) category activation in our theoretical framework.

4.5.1 Cultural image effect

Our theoretical framework predicted that, when a cultural image associated with Māori is presented, NZE speakers may be more likely to produce imported structure in speech [Prediction 3]. Our result indicates that this effect is tentative. As predicted, the rate of importation is slightly higher when a Māori cultural frame is presented than when a neutral cultural frame is presented. However, this difference is not statistically significant (p=0.09). Although it was demonstrated by Hay & Drager (2010) that speech perception is influenced by cultural images as reviewed in 4.2, our result might indicate that speech production is less likely to be affected by cultural images.

Before concluding this section, we would like to point out three possible reasons which may account for the non-significant effect of cultural images on production of a linguistic variant. One reason is that participants took part in this experiment after the passage-reading

task (Experiment 1). As was discussed above, the representation of a social category "Māori" may be already activated to the point of saturation during Experiment 1, and this category activation may have resided until after the experiment. This is why cultural images could not further activate the representations of a social concept "Māori" and imported structure, and they do not change the likelihood of adaptation vs. importation significantly.

Another possibility is that participants could not pay enough attention to cultural images due to the experimental design. In this experiment, a cultural frame and a word both shifted together, when a participant read aloud a word and pressed a space bar. Although the time was not formally measured, a cultural frame may shift every few seconds. As a frame shifts very quickly, speakers may not have looked at frames. Besides, participants focused on a word shown at the centre of a screen, so they may not have looked at a frame shown at the edge of a screen. As a result, their speech production may not be significantly affected by a cultural frame significantly.

The other possibility is due to the nature of a word-list reading task. In Experiment 2, the effects of cultural images were explored using a word-list reading task, which may cause speech to be more careful (Labov 1972). Due to the careful manner, the pronunciation of Māori loanwords becomes less natural and the likelihood of producing imported structure becomes higher in general, as noted above, the result of which is that the effects of cultural images may be concealed. On the other hand, as was seen in the previous chapter, topic effects were explored using a passage-reading task, which may cause speech to be more natural than a word-list reading task, and the effects were found to be statistically significant. Perhaps, the observed difference between topic effects and cultural image effects might be attributed to the difference between a passage-reading task and a word-list reading task. As topics and cultural images both relate to the activation of the social concept Māori, cultural image effects should also be explored in the same way as topic effects using a passage-reading task.

In order to solve these problems, Experiment 3 was designed to make sure that (1) a participant took solely an experiment manipulating a cultural frame, (2) a cultural image stays longer on screen and is shown near stimulus sentences, and (3) cultural image effects are explored using a passage-reading task. The design and the result will be reported in the next chapter.

4.5.2 Speakers' association with source language and culture

It was predicted that, [Prediction 4a] speakers strongly related with Māori may be exposed to imported structure more often and store more exemplars with imported structure, and consequently they are more likely to produce imported structure, and that [Prediction 4b] speakers with positive attitudes towards Māori are more likely to activate a social concept "Māori" and produce imported structure via the socio-indexical link. Prediction 4b was fully supported by the result of Experiment 2 as with Experiment 1. The effect of attitudes (*PC-attitude*) is significant in the predicted direction. This suggests that speakers with more positive

attitudes towards Māori are more likely to produce imported structure. This result corroborates the result of Experiment 1, and it can be captured by hypothesizing that those with positive attitudes towards Māori potentially activate the social concept "Māori," and consequently the representation of imported structure is more likely to be activated via the socio-indexical link.

On the other hand, *PC-culture* and *PC-people* are not significant at all. As was discussed in the previous two chapters, our participants have a very weak relationship with Māori people and speakers, and thus it is unsurprising that *PC-people* is not significant (p=0.81). As for *PC-culture*, this variable showed a trend in Experiment 1 (p=0.08), but it is not significant at all in Experiment 2 (p=0.52). The reason might be due to the fact that the rate of importation is higher in Experiment 2, and the speaker-oriented variation might be concealed by the ceiling effect. This post hoc interpretation might be supported by the fact that the effect of another speaker-specific factor *PC-attitude* becomes weaker in the second session (see Figure 4.4), during which the rate of importation is slightly higher in comparison with the first session. That is, the higher rate of importation might conceal the speaker-oriented variation. Note that the direction of *PC-culture* is still as predicted, that is, speakers strongly related to Māori culture and language are more likely to produce imported structure.

Finally, *speakerPlace* is found to be significant (p<0.01), and the direction is in line with that observed in Experiment 1. That is, North Islanders are more likely to produce imported structure than South Islanders. As was discussed in the previous chapter, this is unsurprising from the perspective of Exemplar Theory. There are more Māori people living in the North Island, so North Islanders may have more opportunities to hear and store imported structure. As a result, they are more likely to produce imported structure because of its potential strength in exemplar space. This is in line with Prediction 4a.

4.5.3 Words' association with source language and culture

We predicted that a loanword strongly associated with Māori is more likely to be produced with imported structure rather than adapted structure [Prediction 5]. This prediction is supported by the result of Experiment 2, that is, the effect of *wordMaoriness* is significant in the predicted direction (p<0.05). Recall that this variable did not achieve significant levels in Experiment 1 (p=0.11), although the direction was as predicted. The reason why this effect becomes statistically significant in Experiment 2 might be the number and type of loanwords employed in this experiment. The set of target loanwords in Experiment 2 is larger than that in Experiment 1, and it includes common nouns as well as place names whereas the set in Experiment 1 includes only place names. Consequently, Experiment 2 may allow us to explore a wider range of words' association with Māori, and this factor achieves significant levels.

This effect can be captured in two ways using exemplar-based approaches. The first interpretation is as in Prediction 5. A loanword strongly associated with Māori is more likely to be heard with imported structure, and consequently exemplars with imported structure have higher strength amongst exemplars belonging to the lexical category. As exemplars with higher

strength are more likely to be chosen in production, imported structure is more likely to be produced for loanwords strongly associated with Māori. The other interpretation is the activation of a social concept "Māori." When speakers produce loanwords strongly associated with Māori, they may also activate the social concept "Māori" potentially via the strong socio-indexical link. As a result, the representation of imported structure, which is associated with the concept as hypothesized in (0c), is also activated, the result of which is that imported structure is more likely to be produced. Note that this interpretation is similar to the theoretical interpretations of topic effects [Prediction 2] and cultural image effects [Prediction 3], in that the activation of the social concept "Māori" raises the activation of imported structure via the socio-indexical link. In either case, this word-specific effect can be captured using the exemplar-based theoretical framework.

4.5.4 Social messages of imported structure and adapted structure

Once again, the result of this experiment suggests that the variation in loanword phonology is socially meaningful. Although intra-speaker variation was not found in accordance with cultural images, the inter-speaker variation was found to be statistically robust. As with Experiment 1, the result of Experiment 2 demonstrates that speakers strongly associated with Māori are more likely to produce imported structure. This finding strengthens the argument for the social messages in the last chapter, i.e., adapted structure [ɹ] carries a social message dissociated from Māori while imported structure [ɾ] carries a social message associated with Māori.

4.6 Summary

Finally, we summarize the findings reported in this chapter. The main aim of this chapter was to explore the effect of cultural images on the likelihood of adaptation vs. importation in production using a word-list reading task. However, the effect of a cultural image was not robust, and it is tentative in our dataset. Although the factor shows a trend in the predicted direction, the p-value was not significant (p=0.09). As was noted in 4.5.1, our experimental design may not be suitable to explore this effect. Hence, Experiment 3 is designed to solve the problems, and the result will be reported in the next chapter. Additionally, speaker-specific and word-specific properties were also examined as in the preceding chapter. The results basically corroborate the finding in the last chapter. First, it was found that speakers with more positive attitudes towards Māori are more likely to produce imported structure. The relationship with Māori culture and language was not a significant predictor, but the direction is as predicted. As for the word-specific property, it was found that loanwords strongly associated with Māori are more likely to be produced with imported structure. As was demonstrated in 4.5, these sociolinguistic effects on the likelihood of importation can be captured by postulating that exemplars with imported structure are stored closely in relation to the social concept "Māori," and that the strength of the exemplars is updated and determined throughout the daily usage.

These theoretical findings in this chapter will be discussed throughout the final chapter, alongside with the findings in Chapters 3 and 5.

As with the last chapter, the findings reported throughout this chapter suggest that the selection of imported structure vs. adapted structure depends on several sociolinguistic factors, and they imply that the variation in loanword phonology can be socially meaningful. That is, it is essential to consider social factors when discussing loanword phonology. In the next chapter, we attempt to replicate the effects reported in this chapter and the preceding chapter.

Chapter 5 Likelihood of adaptation vs. importation III: Effect of topic and cultural Image

5.1 Introduction

The aim of this chapter is to replicate and expand on the sociolinguistic effects discussed in the last two chapters. Chapter 3 has demonstrated that there is a robust effect of topics on the likelihood of adaptation vs. importation, that is, borrowers are more likely to produce imported structure when they read passages about Māori. Although the effect of topics seems to be well-attested, Experiment 1 might have a methodological issue, as discussed in 3.5.5. The issue is that the Māori passages include a few non-target loanwords with /r/ (e.g., *Aotea<u>r</u>oa*, *Māo<u>r</u>i*, *ma<u>r</u>ae*, and *Mata<u>r</u>iki*), whereas the neutral passages do not. According to the result of Experiment 2, these non-target loanwords are strongly associated with Māori, and they are relatively likely to be produced with imported structure. That is, there is a slight possibility that the representation of imported structure [ɾ] is activated by the pronunciation of tap sounds in the non-target loanwords, and the increasing rate of importation might be attributed to the tap sounds in the non-target loanwords rather than the topics of the passages.

Chapter 4 has shown that there is a trend in which imported structure is slightly preferred in comparison to adapted structure when Māori cultural images are presented on a screen, but the cultural image effect was not statistically significant. Hence, it remains unclear whether cultural image effects are genuinely taking place. The possible reason for no significance might be that cultural images changed very fast in the word-list reading task, and thus speakers could not pay enough attention to cultural images. Another reason may be that the effect of topics still lasts even after Experiment 1, and the effect of cultural images was blurred in Experiment 2, see discussion in 4.5.1. It was also pointed out that it is worth exploring cultural image effects in the same way as topic effects, that is, by using a passage-reading task. This would enable us to more directly test whether the topic effect is indeed more robust than the image effect.

In order to solve these issues, another passage reading experiment (Experiment 3) was designed by manipulating both topics and cultural images. First, the new passages employed in this experiment do not include any non-target loanwords with /r/ before target loanwords. This prevents a priming effect from /r/ sounds in non-target loanwords, and solves the methodological issue in Experiment 1. As explained in 5.3, we will compare the topic effects between new passages and old passages (passages employed in Experiment 1), allowing us to test whether the likelihood of adaptation vs. importation is affected by the priming effect from /r/ sounds in non-target loanwords. Second, it is made sure that a cultural image stays on the screen until a participant finishes reading a passage. This allows a cultural image to stay longer on the screen than Experiment 2, and thus a participant should be able to pay more attention to cultural images. Finally, a participant took only Experiment 3. As will be explained below, half

the participants read only neutral passages for the first half of the experiment while seeing either a neutral cultural frame or a Māori cultural frame. This enables us to observe purely cultural image effects without topic effects for these participants. The methodology will be explained in more details in 5.3.

As was stated above, Experiment 3 is designed to replicate and expand on the effects discussed in the last two chapters. That is, this chapter aims to provide insights to *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors* [RQ1a], and investigate whether variation in loanword phonology is socially meaningful. The specific questions are as follows:

(1) Research questions addressed in this chapter
   RQ2: "Is the likelihood of adaptation vs. importation affected by topic in speech?"
   RQ3: "Is the likelihood of adaptation vs. importation affected by cultural images?"
   RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"
   RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

Addressing these questions enables us to increase the understanding of how adapted structure and imported structure are represented in the mind of a borrower. As with the preceding two chapters, we could specifically test the hypotheses about (0) representation of adapted structure and imported structure and (1) category activation in our theoretical framework (see 1.7). As with the preceding two chapters, the results will suggest that variation in loanword phonology is socially meaningful.

This chapter is organized in the following way: Section 5.2 briefly discusses predictions deduced from our theoretical framework that are related to the above four research questions. Section 5.3 explains the experimental methodology, and Section 5.4 outlines the results. Section 5.5 discusses the results, and Section 5.6 summarizes this chapter.

5.2 Predictions

As stated above, this chapter addresses the same research questions as the last two chapters using a different experimental design. Hence, the predictions discussed in this chapter are the same as the preceding two chapters. This is why we will not offer the full explanations for the following predictions. See discussions in 1.8, 3.2 and 4.2 for the details on the theoretical motivation. The hypotheses we will test in the current chapter are those regarding how imported structure and adapted structure are stored and activated in the mind of a borrower.

(1) Four predictions tested in this chapter

Prediction 2: When NZE speakers talk about something related to Māori in speech, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

Prediction 3: When NZE speakers see a cultural image related to Māori when speaking, it activates the representation of imported structure [ɾ], the result of which is that the imported structure is more likely to be produced in speech.

Prediction 4a: If a NZE speaker has a stronger relationship with Māori (i.e., the source language and its culture), the speaker may be exposed to more imported structure and store more exemplars with imported structure, the result of which is that the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

Prediction 4b: If a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori," and consequently the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ].

Prediction 5: If a loanword is more strongly associated with Māori (i.e., the source language and its culture), the loanword may more often be stored with imported structure, the result of which is that the loanword is more likely to be produced with imported structure [ɾ] than adapted structure [ɹ].

5.3 Methodology

This section illustrates the research design employed in the current chapter. As stated in 5.1, Experiment 3 was designed to replicate and expand on the effects discussed in the last two chapters. In this experiment, participants were asked to read passages about Māori and general New Zealand life while seeing either a Māori cultural frame or a neutral cultural frame.

5.3.1 Participants

64 participants took part in this passage-reading task. These participants are different from those participating in Experiments 1 and 2. 40 participants are female, and 24 participants are male. They are aged between 18-35. The participants identify themselves primarily as Pākehā rather than Māori. As with the participants in Experiments 1 and 2, it was ensured that participants are not fluent bilingual speakers of te reo Māori or any other languages. The participants were recruited at the University of Canterbury, and they were interviewed individually by the author. After they finished a passage-reading task, they filled in the questionnaires. They received a 15 NZD voucher at the end of the experiment.

5.3.2 Experiment 3: material and procedure

This experiment is based on Experiment 1, but it manipulates cultural images as well as passage topics. The participants were asked to read 20 short passages, eight of which are Māori

passages, eight of which are neutral passages, and four of which are filler passages (see Appendix F). The target loanwords are the same as those employed in Experiment 1, and they are assembled into four groups as in (2). The 16 non-filler passages include one of the following groups of the target loanwords:

(2) Four groups of target Māori loanwords
Group A: Roto<u>r</u>ua, Ta<u>r</u>anaki, Whanga<u>r</u>ei
Group B: Aka<u>r</u>oa, Ao<u>r</u>aki, Kaikou<u>r</u>a, Moe<u>r</u>aki
Group C: Oama<u>r</u>u, Tau<u>r</u>anga, Tima<u>r</u>u, Toko<u>r</u>oa
Group D: Ma<u>r</u>uia, Pae<u>r</u>oa, Po<u>r</u>i<u>r</u>ua, Rangio<u>r</u>a

As with Experiment 1, all the target loanwords are place names, and they include /r/ sounds, of which the realizations can be classified into adapted structure [ɹ] or imported structure [ɾ] (see 1.6.3). Only the word-medial /r/ is analysed as in Chapter 3. That is, the word-initial rhotics in *<u>R</u>angiora* and *<u>R</u>otorua* are not analysed. Note that the two /r/ realizations in *Po<u>r</u>i<u>r</u>ua* are annotated separately.

The 16 target passages are classified into 4 types of passages: old Māori passages, new Māori passages, old neutral passages, and new neutral passages. Old Māori passages and old neutral passages are the same passages as those employed in Experiment 1. As was pointed out in 3.5.5, old Māori passages include a few non-target loanwords with /r/ (e.g., *Aotea<u>r</u>oa*, *Māo<u>r</u>i*, *ma<u>r</u>ae*, and *Mata<u>r</u>iki*), and this is a methodological issue of Experiment 1, as the topic effects might be confounded with the priming effects from /r/ sounds in non-target loanwords. New Māori passages and new neutral passages are those made only for Experiment 3. As for new passages, it was ensured that non-target loanwords with /r/ do not appear before target loanwords. Hence, the comparison between old passages and new passages allows us to test whether the topic effects observed in Experiment 1 are caused by the priming effects from /r/ sounds in non-target loanwords. As will be discussed in 5.4.2, if the /r/ pronunciation of the non-target loanwords influenced the likelihood of choosing imported structure, then it could be expected that more imported structure should be produced in old Māori passages. The target loanwords all appeared sentence-medially in the four types of passages, and they were mentioned twice within each passage. Hence, 8,192 tokens of /r/ were supposed to be collected (16 word-medial /r/ x 4 types of passages x 2 times mentioned in a passage x 64 participants):

	Old Māori	Old neutral	New Māori	New neutral
Group A loanwords	2	2	2	2
Group B loanwords	2	2	2	2
Group C loanwords	2	2	2	2
Group D loanwords	2	2	2	2

Table 5.1 Number of target loanword mention depending on passage type

The target passages were presented within one of the following cultural frames. The cultural frames are the same as those employed in Experiment 2. The left-hand two cultural frames in Figure 5.1 are supposed to be associated with Māori, whereas the right-hand two cultural frames are supposed to be culturally neutral. As was noted in 4.3.2, it was confirmed by some New Zealanders whether the left-hand frames are Māori-like. Note that only red and black Māori frames and light-brown and dark-brown neutral frames were employed in this experiment:

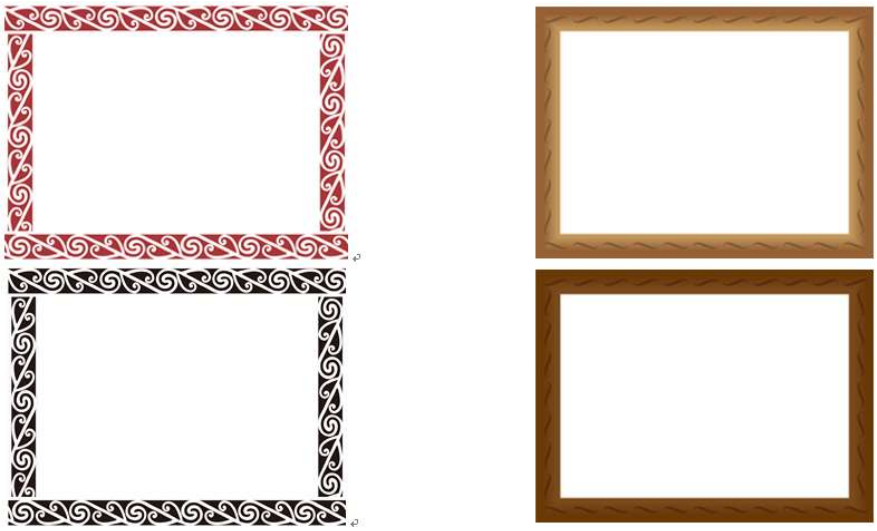

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Figure 5.1 Cultural frames: Māori cultural frame vs. neutral cultural frame

The passages and cultural frames were presented using *E-prime 2.0 software* (Psychology Software Tools, Pittsburgh, PA). Each participant was asked to read the passages in a natural way. At the beginning of each trial, the passage and the cultural frame appeared on the screen of a computer, and remained there for the rest of the trial. After the participants pronounced the whole passage, they pressed the space bar and the next passage and cultural frame appeared on the screen. They repeated this procedure until they finished reading all the twenty passages (eight Māori passages, eight neutral passages, and four filler passages).

The item numbers of the passages and cultural images were pseudo-randomized using R (R Core Team 2016) in the following way. As for passage topics, the passage topic remains the

same for the first eight target passages, and changed from the ninth target passage. The order was counter-balanced: half the participants (P33-P64) read Māori passages first, and the other participants (P65-P96) read neutral passages first. Note that new passages always precede old passages within the same topic. The type of cultural images (Māori vs. neutral) altered every two passages. The order was counter-balanced, that is, some participants read passages while seeing two Māori cultural frames before seeing two neutral cultural frames, whereas the others read passages while seeing neutral cultural frames before seeing two Māori cultural frames. It was made sure that the same cultural frames were not consecutive. For example, if a red Māori frame was presented with a passage, a black Māori frame was presented with the next passage. The combination of passages and cultural frames was also counter-balanced, i.e., half the participants produced Group A and Group B loanwords within a Māori cultural frame first, and the other half of the participants produced Group A and Group B loanwords within a neutral passage first. There was a break between the first eight target passages and the second eight target passages. Filler passages appeared between the first four target passages and the second four target passages and between the third four target passages and the fourth four target passages. Note that the topics of filler passages are neutral or Māori in accordance with the surrounding passages, and the cultural images presented with filler passages are always neutral. The procedure can be summarized as in Tables 5.2 and 5.3. After they took this experiment, they filled in the questionnaires that were also employed in Experiments 1 and 2.

Participants A (P33, P37, P41…)	Participants B (P34, P38, P42…)	Participants C (P35, P39, P43…)	Participants D (P36, P40, P44…)
New neutral A&B with Māori frame New neutral C&D with Neutral frame [2 neutral filler] Old neutral C&D with Māori frame Old neutral A&B with Neutral frame	New neutral A&B with Neutral frame New neutral C&D with Māori frame [2 neutral filler] Old neutral C&D with Neutral frame Old neutral A&B with Māori frame	New neutral C&D with Māori frame New neutral A&B with Neutral frame [2 neutral filler] Old Neutral A&B with Māori frame Old neutral C&D with Neutral frame	New neutral C&D with Neutral frame New neutral A&B with Māori frame [2 neutral filler] Old neutral A&B with Neutral frame Old neutral C&D with Māori frame
<Break>	<Break>	<Break>	<Break>
New Maori A&B with Māori frame New Maori C&D with Neutral frame [2 Māori filler] Old Maori C&D with Māori frame Old Maori A&B with Neutral frame	New Maori A&B with Neutral frame New Maori C&D with Māori frame [2 Māori filler] Old Maori C&D with Neutral frame Old Maori A&B with Māori frame	New Maori C&D with Māori frame New Maori A&B with Neutral frame [2 Māori filler] Old Maori A&B with Māori frame Old Maori C&D with Neutral frame	New Maori C&D with Neutral frame New Maori A&B with Māori frame [2 Māori filler] Old Maori A&B with Neutral frame Old Maori C&D with Māori frame

Table 5.2 Procedure in Experiment 3: Participants 33-64 (neutral topic first)

Participants E (P65, P69, P73…)	Participants F (P66, P70, P74…)	Participants G (P67, P71, P75…)	Participants H (P68, P72, P76…)
New Maori A&B with Māori frame New Maori C&D with Neutral frame [2 Māori filler] Old Maori C&D with Māori frame Old Maori A&B with Neutral frame	New Maori A&B with Neutral frame New Maori C&D with Māori frame [2 Māori filler] Old Maori C&D with Neutral frame Old Maori A&B with Māori frame	New Maori C&D with Māori frame New Maori A&B with Neutral frame [2 Māori filler] Old Maori A&B with Māori frame Old Maori C&D with Neutral frame	New Maori C&D with Neutral frame New Maori A&B with Māori frame [2 Māori filler] Old Maori A&B with Neutral frame Old Maori C&D with Māori frame
<Break>	<Break>	<Break>	<Break>
New neutral A&B with Māori frame New neutral C&D with Neutral frame [2 neutral filler] Old neutral C&D with Māori frame Old neutral A&B with Neutral frame	New neutral A&B with Neutral frame New neutral C&D with Māori frame [2 neutral filler] Old neutral C&D with Neutral frame Old neutral A&B with Māori frame	New neutral C&D with Māori frame New neutral A&B with Neutral frame [2 neutral filler] Old neutral A&B with Māori frame Old neutral C&D with Neutral frame	New neutral C&D with Neutral frame New neutral A&B with Māori frame [2 neutral filler] Old neutral A&B with Neutral frame Old neutral C&D with Māori frame

Table 5.3 Procedure in Experiment 3: Participants 65-96 (Māori topic first)

5.3.3 Questionnaires

5.3.3.1 Speakers' association with Māori

As was explained in Chapter 2, the answers to questionnaires about speakers' association with Māori were reduced to the following principal components. These factors will be fitted in the following statistical models.

(3) Meanings of three principal components

PC-attitude: attitude towards Māori culture and language

PC-culture: relationship with Māori culture and language, and individual proficiency

PC-people: relationship with Māori people, and neighbourhood proficiency

5.3.3.2 Words' association with Māori and word frequency

As was discussed in Chapter 2, speakers subjectively rated loanwords' association with Māori and word frequency. These raw values were z-scored within a speaker, because the ranges of the raw values differ in accordance with the participants (see 2.3.3). Figure 5.2 shows the

distribution of z-scored values of words' association with Māori, and Figure 5.3 shows z-scored values of word frequency. The inside dots indicate the means across speakers. As with the 32 participants in Experiments 1 and 2, *Aoraki* is instinctively felt to be strongly associated with Māori. This may be because *Mt Cook* is more likely to be used to refer to the place within a Pākehā community. Besides, words referring to places near the University of Canterbury (e.g., *Timaru*, *Oamaru* and *Akaroa*) are weakly associated with Māori and instinctively felt to be used more frequently.

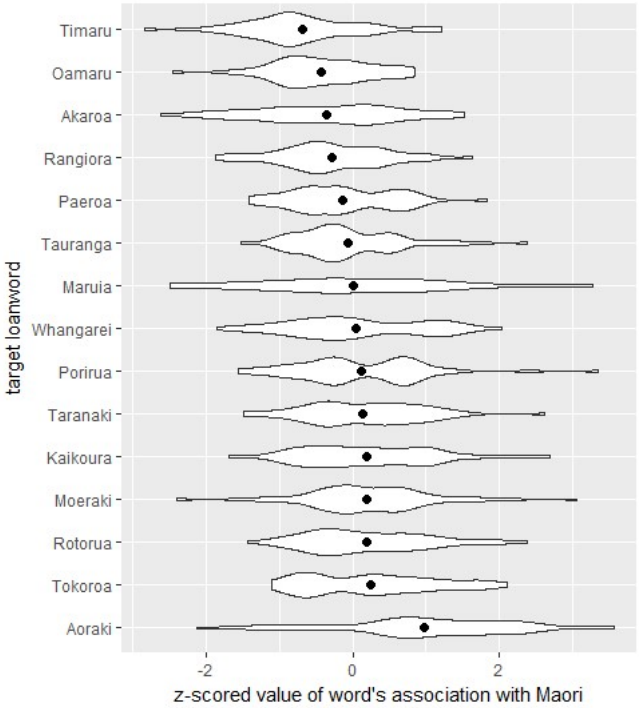

Figure 5.2 Peanut plot for z-scored words' association with Māori

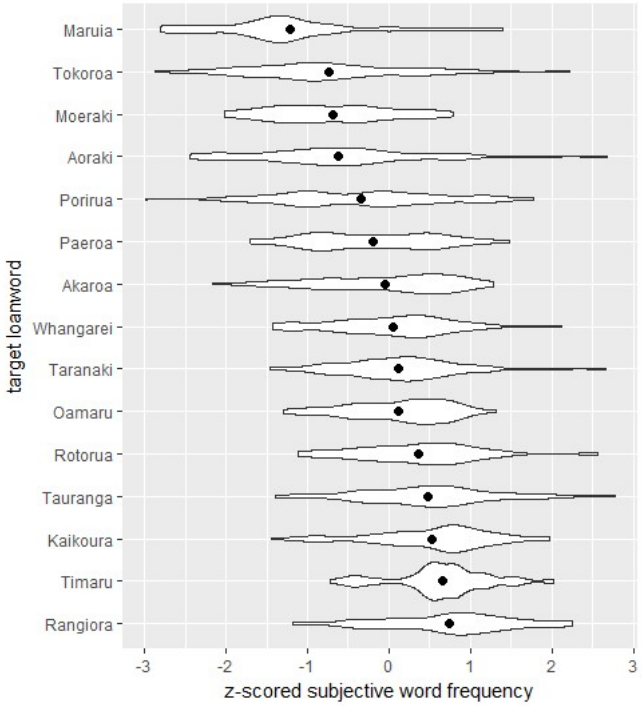

Figure 5.3 Peanut plot for z-scored subjective word frequency

Note that these two variables do not correlate according to Pearson's correlation test (r=−0.15).

5.3.4 Acoustic analyses

As with the last two chapters, the classification of /r/ realizations into adapted structure and imported structure is basically based on the acoustic analyses using Praat (Boersma & Weenick 2016), see 3.3.4 for the acoustic criteria in detail. About 10% of them were impressionistically annotated as explained below.

5.4 Results

The aim of this section is to illustrate the results of the experiment, and discuss the statistical analyses.

5.4.1 Number of observations

As stated in 5.3.1, 8,192 tokens of /r/ were supposed to be collected in Experiment 3. 151 tokens were removed because of mispronunciation or disfluency, and 517 tokens were removed because participants did not know some loanwords (i.e., subjectively rated as 0 with regards to the participants' word frequency). The remaining tokens are shown in Table 5.2.

Annotation	Number
Acoustically identified tap [ɾ]	3,072 (40.8%)
Acoustically identified approximant [ɹ]	3,570 (47.4%)
Impressionistically identified tap [ɾ]	547 (7.3%)
Impressionistically identified approximant [ɹ]	169 (2.3%)
Impressionistically deleted sounds (or others)	166 (2.2%)
SUM	7,524

Table 5.4 Total number of observation

5.4.2 Variables

5.4.2.1 Response variable: adaptation vs. importation

The response variable is a binary variable: adapted structure [ɹ] vs. imported structure [ɾ]. As with the last two chapters, acoustically identified tokens and impressionistically identified tokens were collapsed into a single class and impressionistically deleted sounds were excluded from the statistical analysis, because logistic regression analyses can only handle binary variables. Consequently, 3,739 tokens with adapted structure (50.8%) and 3,619 tokens with imported structure (49.2%) will be fit into a statistical model.

5.4.2.2 Key predictors: topics, cultural images, and association with Māori

The variables of most interest are *topic* (Māori topic vs. neutral topic) and *frame* (Māori cultural frame vs. neutral cultural frame). The tokens produced in Māori passages were coded as Māori topic and those produced in neutral passages were coded as neutral topic. In the same way, the tokens produced while seeing Māori cultural frames were coded as Māori frame and those produced while seeing neutral cultural frames were coded as neutral frame. As some participants began with Māori passages and the others began with neutral topic, *firstTopic* (Māori topic vs. neutral topic) is also explored. For the same reason, *firstFrame* (Māori frame vs. neutral frame) is also analysed.

As with the last two chapters, the speakers' association with Māori is also examined. As was explained above, the three principal components are examined: *PC-attitude* (attitude towards Māori culture and language), *PC-culture* (relationship with Māori culture and language and individual proficiency in te reo Māori), and *PC-people* (relationship with Māori people and neighbourhood proficiency in Māori).

Finally, a word's association with Māori is also a variable of interest. As in the last two chapters, this variable is called *wordMaoriness*. This variable is a z-scored value based on the subjective rating of words' association with Māori.

5.4.2.3 Control variables

As with Experiment 1 (passage-reading task), we also fitted 10 control variables into our

statistical model: *subjFreq*, *wordPlace*, *speakerPlace*, *folSt*, *precSt*, *folBr*, *precBr*, *NofSeg*, *mention*, and *SpRate* (see discussion in 3.4.2.3).

In addition, we also explore *material* (new passages vs. old passages). As was discussed at the end of Chapter 3, old Māori passages include a few non-target loanwords with /r/, and they might cause priming effects on the pronunciation of /r/ in target loanwords. This was the methodological issue in Experiment 1. In order to solve this issue, new passages do not include any non-target loanwords with /r/ preceding target loanwords. If the pronunciation of the non-target loanwords activated the representation of imported structure as pointed out in 3.5.5, then it could be expected that more imported structure should be produced in old Māori passages. That is, the interaction between *material* and *topic* should be statistically significant.

Because of the experimental design, we could not explore the effect of *session*. The reason is that there is a gap in the number of tokens, as long as we explore the variables of interest such as *topic* and *firstTopic*. As was explained in 5.3, half the participants began with Māori passages, and the other half began with neutral passages. That is, the first half of the participants do not read Māori passages in the first half of an experiment, and they do not read neutral passages in the second half of an experiment. The reverse is true for the second. Table 5.5 describes this gap:

Speakers beginning with neutral passages			Speakers beginning with Māori passages		
	First session	Second session		First session	Second session
Māori passage	0	1,820	Māori passage	1,798	0
Neutral passage	1,861	0	Neutral passage	0	1,879

Table 5.5 Gap in number of tokens

If we fit these three variables (i.e., *session*, *topic*, and *firstTopic*) into a statistical model together, *session* is automatically dropped with an error message for this reason. Hence, *session* is not explored in the current chapter. The variables explored in this chapter are summarized in Table 5.6.

topic	Current reading passage is Māori vs. neutral (binary)
firstTopic	First reading passage is Māori vs. neutral (binary)
frame	Presented cultural frame is Māori vs. neutral (binary)
firstFrame	First presented cultural frame is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
subjFreq	Subjective word frequency (numeric)
wordPlace	Place referred to by a target loanword is in the North Island vs. the South Island (binary)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folBr	Target loanword is followed by a prosodic break or not (binary)
precBr	Target loanword is followed by a prosodic break vs. not (binary)
NofSeg	Number of segments within a target loanword (numeric)
mention	Mentioned first within a passage vs. second (binary)
SpRate	Syllables per second (numeric)
material	New passages vs. old passages (binary)

Table 5.6 List of variables examined in statistical analyses

5.4.3 Logistic regression analyses

The 7,358 tokens were hand-fitted into a mixed-effects logistic regression model with bobyqa optimizer using the *glmer* function in the *lme4* library (Bates et al. 2015) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 7 variables (*PC-people*, *speakerPlace*, *folSt*, *folBr*, *precBr*, *NofSeg*, and *SpRate*) were removed one-by-one through pairwise comparisons of models with and without each variable. As for these 7 variables, their interactions with the other variables were not examined, because the model including their interactions did not converge well and their p-values were not significant at all. Then, backward elimination was run manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the remaining 12 variables. The elimination was based on p-value, that is, either a single effect or an interaction with the highest p-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was adopted. Through this process, 4 variables (*subjFreq, wordPlace, precSt,* and *mention*) were removed. Finally, by-participant random slopes for *wordMaoriness*, *topic*, and *material*, and by-word random slopes

for *firstTopic* and *PC-culture* were added to the model, as they improve the model. Then, 2 variables (*wordMaoriness* and *PC-attitude*) were dropped, as their p-values became higher than the threshold of .05. A Variance Inflation Factor (VIF) test was performed on the model, and all VIF scores were below 4, which suggests that there is no multicollinearity in the model. Table 5.7 shows the best-fitted model, with the intercept being `topic neutral`, `firstTopic neutral`, `frame neutral`, `firstFrame neutral`, and `material new`.

imp/adap~topic+firstTopic+frame+firstFrame+PC-culture+material
+frame:firstFrame+topic:firstTopic+topic:material[12]

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.4580	0.8721	-2.818	0.00483	**
topic Maori	1.3496	0.2385	5.660	1.52e-08	***
firstTopic Maori	1.7053	0.9384	1.817	0.06918	.
frame Maori	0.5473	0.1126	4.861	1.17e-06	***
firstFrame Maori	0.7871	0.8615	0.914	0.36086	
PC-culture	1.8977	0.4748	3.997	6.43e-05	***
material Old	0.2706	0.1445	1.873	0.06106	.
frame Maori:firstFrame Maori	-0.9227	0.1573	-5.866	4.45e-09	***
topic Maori:firstTopic Maori	-1.2150	0.2969	-4.092	4.27e-05	***
topic Maori:material Old	0.4781	0.1587	3.013	0.00259	**

Table 5.7 Best-fitted model as a result of backward elimination

As with the last two chapters, the response variable (adapted structure [ɹ] vs. imported structure [ɾ]) is converted to a so-called dummy variable (i.e., 0 is given to the adapted structure [ɹ] and 1 is given to the imported structure [ɾ]) in the above model. Hence, positive coefficients indicate higher likelihood of choosing imported structure, and negative coefficients indicate higher likelihood of choosing adapted structure. Three variables (*topic*, *frame*, and *PC-culture*) are significant as main effects. Two variables (*firstTopic* and *material*) show trends. The two variables (*topic* and *frame*) significantly interact with other variables. Hence, let us first consider each interaction in more detail.

First, the interaction between *frame* and *firstFrame* suggests that the effect of *frame* differs in accordance with *firstFrame*. This is illustrated in Figure 5.4. The left-hand figure shows the raw probability, and the right-hand figure shows the probability predicted by the best-fitted model. As shown in these figures, the direction of *frame* is different when *firstFrame* is neutral and when *firstFrame* is Māori. We performed the subset analyses, and it was found that the effect of *frame* is significant both when *firstFrame* is neutral (β=0.56, z=4.91, p<0.001) and

[12] We performed subset analyses including only acoustically identified tokens, and it was found that the significance of these variables does not change basically.

when *firstFrame* is Māori (β=−0.39, z=−3.5, p<0.001). That is, speakers exposed to a neutral frame at the beginning of the experiment are more likely to produce imported structure while seeing a Māori cultural frame; those exposed to a Māori cultural frame at the beginning are more likely to produce imported structure while seeing a neutral frame.

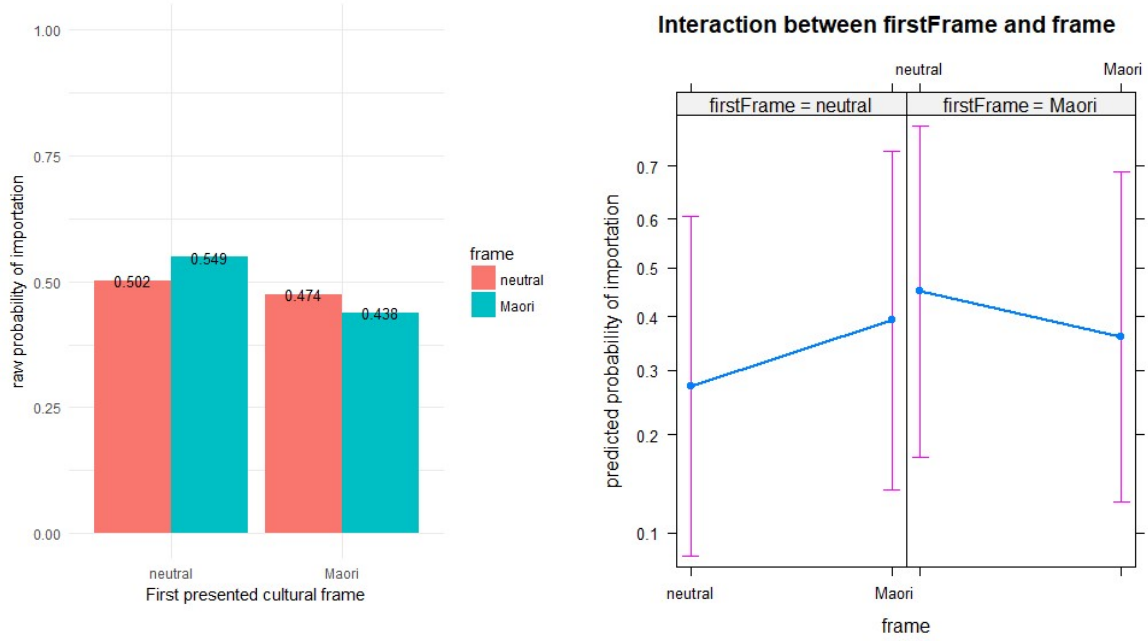

Figure 5.4 Interaction between firstFrame and frame

Second, the interaction between *firstTopic* and *topic* suggests that the effect of *topic* is different when *firstTopic* is neutral and when *firstTopic* is Māori. As is shown in Figure 5.5, the direction of the slope is the same, but the slope of *topic* is steeper when participants begin with neutral passages. Once again, the subsets of the data were explored, and it was found that the effect of *topic* is significant (β=1.62, z=4.99, p<0.001) only when *firstTopic* is neutral; while it was not significant (β=0.009, z=0.04, p=0.96) when *firstTopic* is Māori. That is, only speakers beginning with neutral passages change their importation rate in accordance with a passage topic, and they are more likely to produce imported structure when reading Māori passages. Note that there is a slight trend that speakers beginning with Māori passages produce a higher rate of imported structure than those beginning with neutral passages (p=0.06).

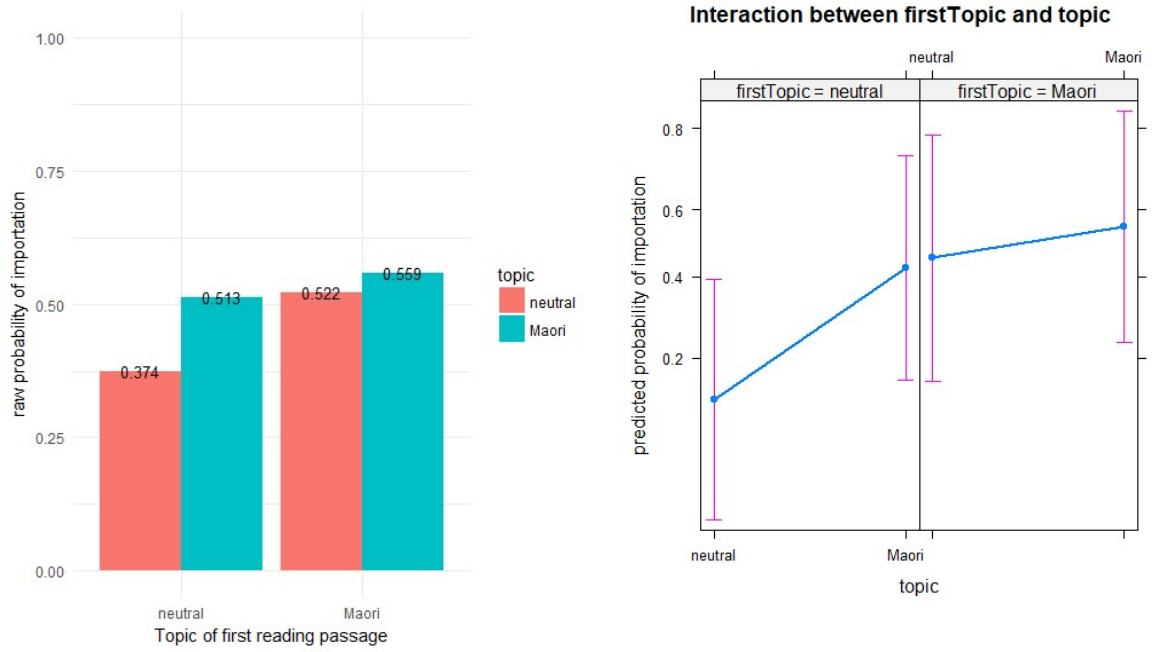

Figure 5.5 Interaction between firstTopic and topic

The final significant interaction is between *topic* and *material*. As is shown in Figure 5.6, this interaction suggests that topic effects are more robust when reading passages are old passages than when reading passages are new passages. Once again, we performed the subset analyses, and it was found that the effect of *topic* is significant both when *material* is new (β=1.32, z=4.84, p<0.001) and when *material* is old (β=1.81, z=6.28, p<0.001). That is, although the effect of *topic* is significant in either case, the magnitude of the topic effects is significantly greater among old passages than among new passages. Note that there is a slight trend that speakers are likely to produce imported structure when reading old passages than when reading new passages (p=0.06).

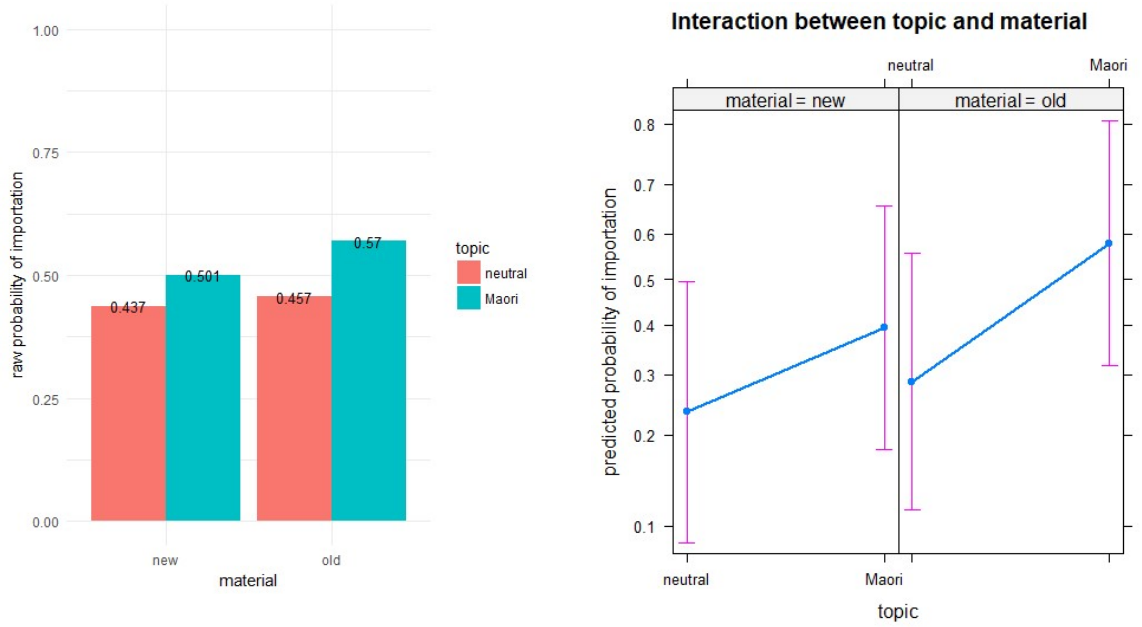

Figure 5.6 Interaction between topic and material

The findings about speakers' association with Māori are essentially the same as those in Chapter 3. First, *PC-culture* is statistically significant (β=1.89, z=3.99, p<0.001). This suggests that speakers strongly associated with Māori language and culture are more likely to use imported structure. Second, *PC-attitude* showed a trend (p=0.07), and it was removed from the best-fitted model as the p-value is lower than the threshold of 0.05. Note that this variable was statistically significant before we added random slopes to the model (p<0.05). Once again, *PC-people* was not significant at all (p=0.36). Differently from Experiment 1, *speakerPlace* is not significant at all (p=0.66).

As for words' association with Māori, *wordMaoriness* is non-significant (p=0.18), although the slope is in the predicted direction (i.e., the slope is positive). Differently from Experiment 1, *wordPlace* is not significant at all (p=0.48).

The other control variables do not achieve sufficiently significant effects (p<0.05), and they were removed through model comparisons.[13] Table 5.8 summarizes variables showing significant effects and those showing trends. Variables showing trends are shaded.

[13] One of the external examiners suggested that *gender* should be taken into consideration. This variable in Experiment 3 is better-balanced in comparison with that in Experiments 1 and 2 (see 2.2.1), and thus I added *gender* to the best-fitted model as a follow-up analysis. It was found that *gender* does not have a significant effect on the likelihood of adaptation vs. importation in our dataset (p=0.21).

topic	When a passage is about Māori, speakers are more likely to produce imported structure (p<0.001). This effect is more robust when *material* is old (p<0.01). Speakers beginning with Māori passages do not show this topic effect (p=0.96).
firstTopic	Speakers beginning with Māori passages are more likely to produce imported structure (p=0.06).
frame	Speakers exposed to neutral frames at the beginning are more likely to produce imported structure while seeing Māori cultural images (p<0.001); those exposed to Māori cultural frames at the beginning are more likely to produce imported structure while seeing neutral cultural images (p<0.001).
PC-attitude	Speakers with more positive attitudes towards Māori are more likely to produce imported structure (p=0.07).
PC-culture	Speakers strongly related with Māori culture and language are more likely to produce imported structure (p<0.001).
material	Speakers are more likely to produce imported structure when reading old passages (p=0.06).

Table 5.8 Summary of findings in Experiment 3

5.5 Discussion

The aim of this section is to discuss the statistical results in relation to the hypotheses that were assessed in the previous two chapters. As in the last two chapters, it was found that young NZE speakers import non-native structure [ɾ] quite often when they produce Māori loanwords. Our dataset has 3,739 tokens with adapted structure (50.8%) and 3,619 tokens with imported structure (49.2%). This overall rate is almost the same as that in the other passage-reading task (Experiment 1), in which 51.1% of /r/ were realized as imported structure. Figure 5.7 shows the rate of importation in accordance with speakers.

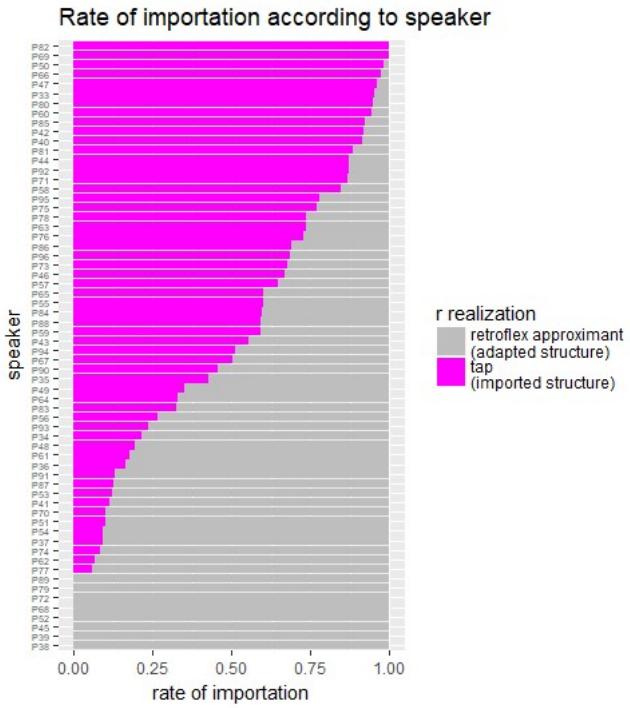

Figure 5.7 Rate of importation according to speaker

Let us, now, discuss the control variables. Once again, phonological variables such as *precBr* and *folBr* did not show significant effects, as expected. As in the last two chapters, *subjFreq* was not found to be significant in the current study, despite the fact that previous literature (e.g., Haugen 1950) demonstrates that higher frequency loanwords are likely to undergo adaptation. The reason might be that subjective word frequency is employed in the current study, see discussion in 3.5 and Lev-Ari et al. (2014), or that all the words examined in this experiment are place names and they all have a low frequency in daily usage. The significant effect of *PC-culture* might be interpreted to mean that higher individual proficiency in te reo Māori causes higher likelihood of importation, as pointed out by Poplack et al. (1988). However, we believe that the effect of proficiency is not so robust in the current study, because no participants in the experiment are fluent speakers of te reo Māori and the contribution of proficiency to *PC-culture* is not so large, see discussion in 3.5. Two control variables *speakerPlace* and *wordPlace* show neither significant effects nor trends in Experiment 3, although they show a trend in Experiment 1. This might be because the current chapter explores a larger number of key and control variables than Chapter 3, and the variables are less likely to achieve significant levels. The control variable *material* shows a trend (p=0.06). This suggests that imported structure is slightly more likely to be produced in old passages than in new passages. This could be interpreted in two ways. The first interpretation is that the pronunciation of [ɾ] in non-target loanwords activates the representation of imported structure, as expected in 5.4.2.3. Recall that old Māori passages include a few non-target loanwords with /r/, whereas new Māori passages do not include those loanwords. Hence, old Māori passages might cause priming effects from the pronunciation of the non-target loanwords. This interpretation is

supported by the fact that topic effects are more robust among old passages than among new passages. This interaction between *material* and *topic* will be discussed in 5.5.1 in further detail. The other interpretation is that the representation of [ɾ] is activated further, as the experiment progresses. As will be discussed in 5.5.2, the rate of importation increases in general as the experiment progresses. Old passages always follow new passages in this experiment, as explained in 5.3.2. That is, the higher importation rate in old passages might be solely due to the order.

In what follows, we will discuss the variables of interest. As will be discussed below, most of the results are in line with the five predictions in 5.2, and corroborate the results reported in the last two chapters. As with the discussions in the preceding two chapters, the following discussions increase the understanding of how adapted structure and imported structure are represented in the mind of a borrower, and suggest that the variation in loanword phonology is socially meaningful.

5.5.1 Topic effect

Our prediction is that, speaking about Māori activates the social concept "Māori" and the representation of imported structure, and consequently imported structure is more likely to be produced [Prediction 2]. The result reported in this chapter shows a robust topic effect on the likelihood of adaptation vs. importation, and the direction is as previously predicted. As with Chapter 3, the current chapter demonstrates that topic effects can extend to loanword phonology.

It is worth commenting on the significant interaction between *topic* and *firstTopic*. It was found that speakers beginning with neutral passages increase their importation rate in accordance with passage topics, but those beginning with Māori passages do not change, see Figure 5.5. This result corroborates the finding in Experiment 1 reported in Chapter 3. Our interpretation is as follows (see also 3.5.1). The representations of social concept "Māori" and imported structure are not especially activated before the experiment. Namely, the likelihood of activating adapted structure or imported structure depends on the potential strength of each structure at the given stage in the experiment. Note that the potential strength is determined by the number of exemplars with imported structure and those with adapted structure in the exemplar space, and thus it differs in accordance with speakers and loanwords. As in Prediction 2, when the participants read Māori passages, the social concept "Māori" starts to be activated, and consequently the representation of imported structure [ɾ] becomes more likely to be activated via the socio-indexical link. As for the participants beginning with neutral passages, this activation occurs in the middle of the experiment. Hence, the rate of importation significantly increases when a passage topic shifts from neutral to Māori. On the other hand, as for the participants beginning with Māori passages, this activation of the social concept "Māori" and imported structure takes place at the very beginning of the experiment. The extra activation may continue to some extent, even after a passage topic shifts from Māori to neutral. Hence, the rate of importation does not significantly change in accordance with passage topics.

Finally, let us discuss the significant interaction between *topic* and *material*. It was found that topic effects are more robust among old passages than among new passages, see Figure 5.6. As expected in 5.4.2.3, this might be because old Māori passages include a few non-target loanwords with /r/ such as *Aotearoa* and *marae*, which are relatively likely to be produced with imported structure [ɾ] in Experiment 2. That is, in addition to topic effects, the pronunciation of [ɾ] sounds in these loanwords might further activate the representation of imported structure, and therefore the importation rate largely changed between old neutral passages and old Māori passages. On the other hand, in new Māori passages, non-target loanwords with /r/ do not appear before target loanwords. Hence, this priming effect does not occur, and only Māori topics might activate the representation of imported structure. As a result, the importation rate does not change so largely between new Māori passages and new neutral passages in comparison to between old Māori passages and old neutral passages.

To sum up, the effect of *topic* is robust in the current study. The results in Experiments 1 and 3 both strongly supported our prediction [Prediction 2]. The results of the two experiments will be discussed alongside each other in Chapter 8.

5.5.2 Cultural image effect

Our theoretical framework predicts that, when a cultural image associated with Māori is presented, NZE speakers may be more likely to produce imported structure in speech [Prediction 3]. The result relevant to this prediction seems the most difficult to interpret. The significant interaction between *frame* and *firstFrame* indicates that speakers exposed to neutral frames at the beginning of the experiment are more likely to produce imported structure while seeing Māori cultural frames; those exposed to Māori frames at the beginning are more likely to choose imported structure while seeing neutral cultural frames, see Figure 5.4. That is, those exposed to neutral frames at the beginning are affected by cultural images in the predicted manner, whereas those exposed to Māori frames are affected by images in the direction opposite to what was predicted.

In fact, this significant interaction might be due to solely the order of cultural frames. As was explained in 5.3.2 (and see Tables 5.2 and 5.3), speakers exposed to neutral frames at the beginning have more opportunities to pronounce loanwords while seeing Māori frames later in the experiment, and those exposed to Māori frames at the beginning have more opportunities to pronounce loanwords while seeing neutral frames later in the experiment. Although we could not fit *session* into the statistical model due to the gap in the number of tokens (see 5.4.2.3 and Table 5.5), our data suggests that imported structure is likely to be produced later in the experiment. Recall that the order effect (i.e., *session*) was also observed in Experiment 1 (see Table 3.5). In 3.5.1, this order effect was captured by positing that the representation of imported structure is activated further by reading more Māori passages and pronouncing more loanwords. Figure 5.8 shows the rates of importation in the first half of the experiment and in the second half of the experiment in Experiment 3. The rate of importation is 46.5% for the first

half, and it is 51.7% for the second half. That is, the rate of importation increases as the experiment progresses. It could be speculated that this significant interaction might be caused by the mere fact that target loanwords are pronounced within a Māori frame later in the experiment by speakers exposed to neutral frames at the beginning, with the reverse being true for those exposed to Māori frames at the offset.

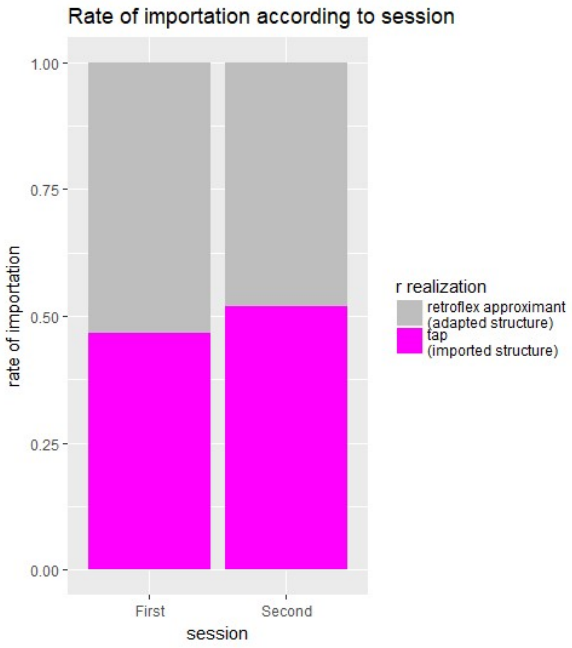

Figure 5.8 Rate of importation according to session

Finally, we would like to point out that the interaction between *frame* and *firstTopic* was non-significant. As explained in 5.3.2, half the participants read the neutral passages before they read the Māori passages. That is, these participants are not exposed to Māori topics for the first half of the experiment, and thus they could be affected only by alternating cultural images. On the other hand, half of participants read the Māori passages for the first half of the experiment, and they could be affected by Māori topics as well as cultural images at the beginning of the experiment. No significance of the interaction between *frame* and *firstTopic* suggests that the effect of *frame* does not differ between the two groups of the participants. That is, *frame* does not affect the likelihood of adaptation vs. importation even when controlling *topic*.

In summary, the cultural image effect is nuanced in the current study. This factor showed a trend in Experiment 2, and the effect might be confounded with the order effect in Experiment 3. That is, our prediction [Prediction 3] is not well-supported by the set of our experiments. This yields a question about the difference between topics and images. Namely, why are topic effects robust and image effects not? This might be due to the degree of consciousness. As pointed out in 1.6.1, alternating images may be less explicit in comparison to alternating topics in speech, because the exposure to a cultural image is subtle and it is not exactly a part of a speech act. Our speculation is as follows: Because of the different degrees of consciousness, Māori topics

may strongly raise the activation of the social category "Māori," the result of which is that the linguistic category called "imported structure" is activated sequentially; Māori images may raise the activation of the social category weakly, and the activation is not strong enough to activate imported structure. Hence, topics could change the importation rate significantly, but images could not.

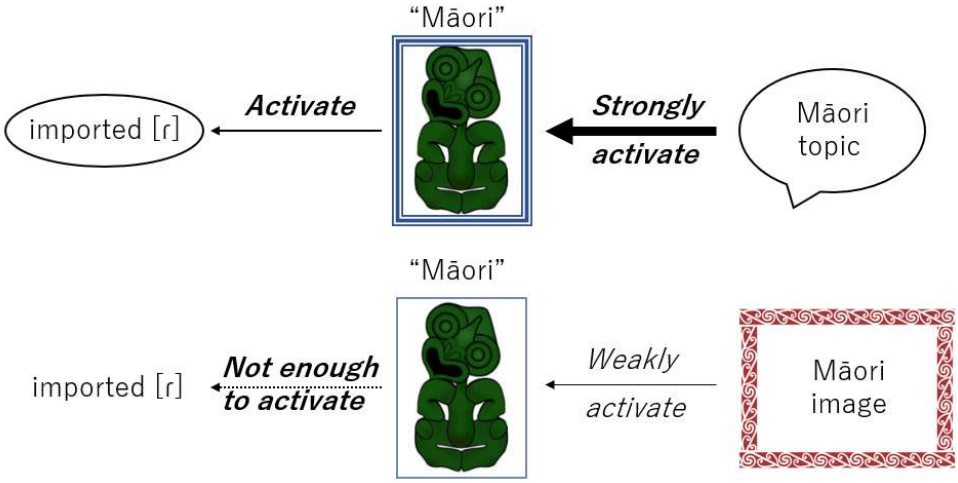

Figure 5.9 Difference in social category activation between topic and image

One might wonder why Hay & Drager (2010) observed the image effects on dialect perception (see 4.2.2.1). The reason might be that they explored gradient difference between vocalic variants (e.g., higher [ɪ] ⇔ lower [ɪ]), while the categories discussed in the current thesis have a discrete nature (i.e., tap [ɾ] vs. approximant [ɹ]). It could be speculated that shifts between discrete categories require stronger activation of categories in comparison to gradient shifts, because exemplars belonging to different discrete categories may not be stored so closely as those belonging to a gradient continuum. This may be why alternating images could not significantly influence the likelihood of choosing a variant in the current study.

5.5.3 Speakers' association with source language and culture

The two predictions about speakers' association with Māori were deduced from our theoretical framework: [Prediction 4a] if a NZE speaker has stronger relationship with Māori (i.e., the source language and its culture), the speaker may be exposed to imported structure and store more exemplars with imported structure, the result of which is that the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ]; [Prediction 4b] if a NZE speaker has more positive attitudes towards Māori (i.e., the source language and its culture), the speaker may be more likely to activate a social concept "Māori" potentially, and consequently the speaker is more likely to produce imported structure [ɾ] than adapted structure [ɹ]. These predictions are supported by the result of this experiment, which basically corroborates the result of Experiment 1, that is, *PC-attitude* and *PC-culture* show either a

significant effect or a trend in the predicted direction.

Prediction 4a (relationship with Māori) is statistically supported to some extent. We explored two variables related to this prediction: *PC-culture* (relationship with Māori culture and language and individual proficiency in Māori) and *PC-people* (relationship with Māori people and neighbourhood proficiency in Māori). As with Experiment 1, *PC-people* is not significant at all (p=0.36). As was discussed in 3.5.2, this might be because the participants in the current study equally have a very weak relationship with Māori people and speakers, see also 2.2.2.3. On the other hand, *PC-culture* is statistically significant (p<0.001). This suggests that speakers strongly related with Māori culture and language are more likely to produce imported structure. This finding supports Prediction 4a, namely, speakers strongly related with Māori culture and language are more often exposed to the use of imported structure. Consequently, the potential strength of the representation of imported structure becomes higher in the cognitive systems of those speakers, and the imported structure is more likely to be activated and chosen in the production of loanwords. As was discussed in 3.5.2, our result suggests that speakers could store a larger number of exemplars with imported structure, as long as they have a strong relationship with Māori cultural events or places and Māori media even though their relationship with Māori people and speakers is weak.

On the other hand, Prediction 4b (attitudes towards Māori) is not statistically supported. Although *PC-attitude* does not achieve sufficiently significant effects, this variable shows a trend (p=0.07), which suggests that there is a slight tendency that speakers with more positive attitudes towards Māori are more likely to produce imported structure. Note that this variable was statistically significant without random slopes. This tendency is in line with Prediction 4b. Speakers with more positive attitudes towards Māori may activate the social concept Māori, and consequently imported structure is activated via the socio-indexical link and chosen in production.

In this way, the results of the experiment reported in the current chapter basically support our predictions about relationship with Māori [Prediction 4a] and attitudes towards Māori [Prediction 4b]. These findings will be discussed in Chapter 8 again, along with the findings in the preceding two chapters.

5.5.4 Words' association with source language and culture

It was predicted that words strongly associated with Māori are more likely to be produced with imported structure, as they are used more frequently in Māori community and are more likely to be stored with imported structure [Prediction 5]. However, *wordMaoriness* is not significant in Experiment 3 (p=0.18). Hence, the result of the experiment reported in the current chapter does not support this prediction.

Recall that this variable showed a significant effect in Experiment 2 (a word-list reading task) reported in the last chapter, but it shows no significant effect in Experiment 1 (a passage-reading task) reported in Chapter 3. As was discussed in 3.5.3, the fact that this variable in the

passage-reading task was non-significant might be due to the fact that the task explores a smaller type of loanwords in comparison to the word-list reading task, and the target loanwords are only place names. The narrow set of targets may not allow us to explore a variety of degrees of words' association with Māori, and thus this variable does not achieve a sufficiently significant effect. Similarly, we could account for the null result in Experiment 3, as the set of the target loanwords is the same as that employed in Experiment 1. These findings will be discussed in Chapter 8 alongside each other.

5.5.5 Social message of imported structure and adapted structure

As with Experiments 1 and 2, the result of Experiment 3 suggests that the variation in loanword phonology is socially meaningful, and the variants carry different social messages. First, our result suggests that this variation is an inter-speaker variation, as speakers strongly associated with Māori are more likely to produce imported structure than those weakly associated with Māori. Next, the statistical significance of the topic effect suggests that it is also an intra-speaker variation. That is, speakers could stylize their speech by choosing the variants (i.e., adapted structure and imported structure) according to a topic in speech. On the basis of the inter-speaker variation, we posit that the two variants in the NZE loanword phonology carry the following social messages, see also the discussion in 3.5.4:

(4) Social messages carried by adapted structure and imported structure in loanwords

Variation	Variant	Carried messages
/ɹ/	[ɹ]	Social message dissociated from Māori
	[ɾ]	Social message associated with Māori

5.6 Summary

Finally, we summarize our findings in this chapter. On the basis of the results in the previous two chapters, this chapter expanded on the effects of sociolinguistic factors on loanword phonology by running another passage-reading task. More specifically, we explored four factors: [RQ2] topic in speech, [RQ3] cultural images, [RQ4] speakers' association with the source language and its culture, and [RQ5] words' association with the source language and its culture. First, the topic effect is robust, and as predicted, it was found that imported structure is more likely to be produced when reading Māori passages. This corroborates the finding in Chapter 3. Second, the cultural image effect was found to be nuanced. It was observed that speakers exposed to neutral frames at the beginning of the experiment are affected by cultural images in the predicted manner, while those exposed to Māori frames at the beginning are affected in the opposite manner. It was speculated in 5.5.2 that this might be solely due to the order of presented frames. Next, speakers' association with Māori is also found to affect the likelihood of adaptation vs. importation. *PC-culture* (relationship with Māori culture and

language) is significant, whereas *PC-attitude* (attitudes towards Māori culture and language) shows a trend in the predicted direction. These results basically corroborate the findings in the last two chapters, and suggest that speakers strongly associated with Māori are more likely to produce imported structure. Finally, it was found that words' association with Māori is not a significant predictor. As was pointed out above, this might be because the passage-reading task employs a narrow set of loanwords and it does not enable us to explore a variety of degrees of words' association with Māori. As discussed above, these sociolinguistic effects can be neatly captured by our theoretical framework based on Exemplar Theory (see 1.7). More specifically, they can be accounted for by positing that exemplars with imported structure are stored closely in relation to a social concept "Māori," and that the strength of imported structure is updated and determined in the daily usage. The overall discussion of the findings in Chapters 3-5 will be offered in Chapter 8.

As with the last two chapters, the findings reported throughout this chapter suggest that the selection of imported structure vs. adapted structure depends on a variety of sociolinguistic factors. That is, it is essential to consider social factors when discussing loanword phonology, and the variation in loanword phonology could be socially meaningful. On the basis of the patterns of the variation, it was proposed that adapted structure [ɹ] carries a social message dissociated from Māori while imported structure [ɾ] carries a social message associated with Māori. On the basis of this argument, the next two chapters address another concrete research question [RQ1b]: *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message*.

Chapter 6 Phonetic implementation I: Redundancy in imported structure [ɾ]

6.1 Introduction

In the last three chapters, we have addressed the overarching research question, *how imported structure and adapted structure are stored in the mind of a borrower and processed in the production of loanwords* [RQ1], by investigating *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors* [RQ1a]. Our results indicate that the likelihood of choosing adapted structure vs. imported structure is affected by several sociolinguistic variables (i.e., topic in speech, speakers' association with Māori, and words' association with Māori), and they support the hypotheses about representations of adapted structure and imported structure (see 1.7). The results suggest that the variation in loanword phonology is socially meaningful, as it is an intra-speaker as well as an inter-speaker variation. Namely, adapted structure and imported structure carry different social messages (see 3.5.4).

This chapter and the next chapter will address the overarching question by examining more phonetic aspects of adapted structure and imported structure. More specifically, we will investigate *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message* [RQ1b]. It will be clarified whether and how the redundancy in imported structure and adapted structure is realized in accordance with their selection predictability. The current chapter focuses on the redundancy of imported structure and addresses the following question:

(1) Research question addressed in this chapter

RQ6: "Is the duration of imported structure affected by the predictability of the social message (i.e., the selection predictability of imported structure)?"

Addressing this concrete research question informs the understanding of how imported structure is processed in the production of loanwords. We could test mainly the hypotheses about (0) predictability representation and (3) articulatory biases in our theoretical framework (see 1.7).

As will be discussed below, social message predictability in the context of redundancy in linguistic signals, has not, to our knowledge, been discussed in previous literature. Hence, this chapter contributes to the general linguistic literature in addition to the specific literature about loanword phonology by developing our understanding of the relationship between the realization of a message and the predictability.

This chapter is organized in the following way. In Section 6.2, we will review relevant

parts of the theoretical framework constructed in Chapter 2 and deduce predictions relevant to the above research question. Section 6.3 explains the methodology to explore the effect of social message predictability on the redundancy of imported structure. In Sections 6.4 and 6.5, we will present the statistical analyses of the data, and we will discuss the results in Section 6.6. Finally, we will summarize this chapter in Section 6.7.

6.2 Background

6.2.1 Theoretical framework: probability and articulatory biases

In Chapter 1, a theoretical framework was developed on the basis of Exemplar Theory (Pierrehumbert 2001; 2002) and MOP (Hall et al. 2016; 2018). Let us review some parts of the theoretical framework relevant to the research question [RQ6]. The hypotheses we will test in the current chapter are those regarding how imported structure and adapted structure are processed in the mind of a borrower.

First, it was assumed that linguistic knowledge is built by representing in memory tokens of previously encountered speech, and that they are stored with detailed phonetic information. These episodic memories are called exemplars. Exemplars with similar linguistic properties cluster together, and a phonological category (i.e., allophone and phoneme) and a lexical category (i.e., lexeme or word) are formed. That is, exemplars and categories are both represented in the mind, and a category is associated with a large number of exemplars (Pierrehumbert 2001; 2002). An exemplar can simultaneously be associated with a variety of categories. On the basis of these exemplars and categories in the cognitive system, it follows that the statistical properties of word-specific and speaker-specific (i.e., system-specific) variation should be retrievable.

In the case of NZE loanword phonology, the ratio of imported structure and adapted structure, given a loanword and a speaker, could be retrieved from the number of exemplars associated with each lexical category and within the whole cognitive system. Figure 6.1 illustrates how the probability of imported structure and adapted structure can be retrieved from the mental representation. In this hypothetical case, there are three exemplars with adapted structure and one exemplar with imported structure amongst exemplars associated with the lexical category *Timaru*. Hence, it follows that the probability of adapted structure *p*(ɹ|Timaru) is 75% and that of imported structure *p*(ɾ|Timaru) is 25%. Similarly, the probability of each structure given a speaker could also be retrieved. This cognitive system (i.e., speaker) has 9 exemplars with adapted structure and 7 exemplars with imported structure. On the basis of this total number, it follows that the probability of adapted structure given this speaker *p*(ɹ|speakerX) is 56.3% and that of imported structure *p*(ɾ|speakerX) is 43.7%. In this way, statistical properties of word-specific and speaker-specific variation could be retrieved on the basis of the associations between categories and exemplars.

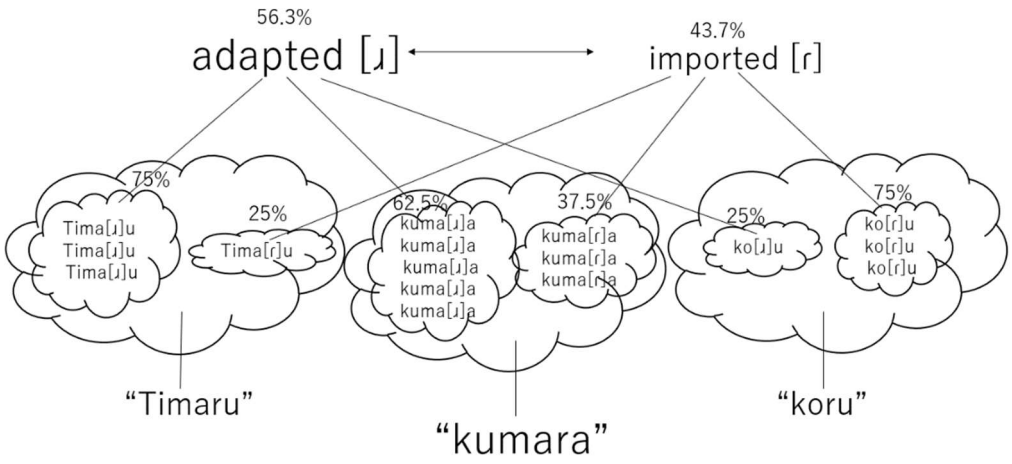

Figure 6.1 Representation of probability of imported structure and adapted structure given speaker and word

As is demonstrated above, an exemplar-based approach naturally predicts that the probability of each structure given a loanword and a speaker could be retrieved on the basis of mental representations. Hence, we hypothesize that (0d) the probability of adapted structure and imported structure given a loanword is represented in the mind of a NZE speaker, because it can be retrieved from the number of exemplars with adapted structure and imported structure associated with a particular lexical category. Further, we hypothesize that (0e) the probability of adapted structure and imported structure given a speaker is also represented in the mind of the NZE speaker, because it can be retrieved from the number of exemplars with adapted structure and imported structure within the cognitive system of a particular speaker.

The other relevant part of our theoretical framework is about articulatory biases. Recall that we assumed in 1.7.3 that (2c) several exemplars surrounding the chosen exemplar are picked up, and the average phonetic value of the chosen exemplars becomes a production target. After the production target is determined, it undergoes production biases (Pierrehumbert 2001). These biases may include social biases as well as articulatory biases. For simplicity, the current study focuses on communication-based articulatory biases. MOP hypothesizes that speakers use “the right sort of redundancy” to avoid “inefficient redundancy,” and thereby augment “the likelihood of sufficiently accurate and cost-effective message transmission” (Hall et al. 2016: 32). That is, this approach hypothesizes that effective communication involves balancing resource cost and message transmission accuracy, and this “effective trade-off” results in phonetic variability. Consequently, this theoretical framework predicts that redundancy in a signal is determined by the probability of accurate message transmission, i.e., redundancy will be increased (thereby increasing the accuracy) when the probability of accurate message transmission is lower than sufficient, whereas redundancy will be decreased (thereby decreasing the resource cost) when the probability of accurate message transmission is higher than sufficient. Note that the accuracy of message transmission is potentially higher when the message is more predictable given the context (see 1.7.4 for detailed discussion). On the basis

of these hypotheses, the following principle could be formulated:

(1) Signal modification principle: effective trade-off between accuracy and resource cost (Hume 2016: 110)
a. Increase redundancy in a signal when the message carried by the signal is less predictable given the context (i.e., the message predictability is lower), thereby increasing the accuracy.
b. Decrease redundancy in a signal when the message carried by the signal is more predictable given the context (i.e., the message predictability is higher), thereby increasing the efficiency.

This signal modification principle is reflected in production biases to reduce or enhance articulatory redundancy in the current study. That is, the current study hypothesizes that the production target determined by exemplar selection is guided by this principle: redundancy is added to the production target when the message it carries is less predictable, and thereby the probability of accurate message transmission is enhanced; redundancy is reduced from the production target when the message it carries is more predictable, and thereby the efficiency of message transmission is enhanced (see Figure 1.12 in Chapter 1).

In the case of NZE loanword phonology, we argued that (3a) the adaptation vs. importation is sociolinguistically meaningful variation, and that adapted structure and imported structure carry different social messages respectively. This is well-supported by both an inter-speaker variation and an intra-speaker variation, as discussed in the previous three chapters. In addition, we hypothesize that (3b) speakers are likely to add more redundancy to a production target when its social message is less predictable given the context, and vice versa. This hypothesis is based on the signal modification principle (1), as a social message is a part of the conveyed message. Next, we hypothesize that (3c) the predictability of the social message carried by imported structure is represented by the selection predictability of imported structure [ɾ] as opposed to adapted structure [ɹ] given a context, because the social message is expressed by choosing one of the two variants. The context is defined as a word and an individual speaker, as deduced by exemplar space (see Figure 6.1). Finally, we hypothesize that (3d) the redundancy of imported structure (i.e., a tap sound) correlates with the duration. That is, lengthening the formant cessation could increase the signal specificity of imported structure [ɾ] (i.e., further differentiate the variant from the competing variant [ɹ]), thereby conveying a social message associated with Māori more accurately (see Figure 1.13). The lack of formant structure is a key cue to imported structure, as it is characteristic of a tap sound while formant structure occurs in an approximant. Lengthening the formant cessation also incurs resource cost, as it requires longer and more careful articulation. In this way, taking more time to produce imported structure increases signal specificity and the accuracy of conveying the social message, while it requires more articulatory redundancy and decreases the efficiency of the message transmission.

6.2.2 Predictions

This section aims to review previous studies related to probabilistic reduction, and deduce the prediction in relation to social message predictability on the basis of our theoretical framework. Although social message predictability has not, to the best of our knowledge, been discussed in previous literature, lexical message predictability has been well-discussed in relation to reduction of linguistic signals (Jurafsky et al. 2001; Bell et al. 2003; 2009; Gahl 2008; Baker & Bradlow 2009; Seyfarth 2014 among others). Note that lexical message predictability can be represented by the predictability of a word, because a lexical message is always carried by a word. For example, it can be defined as the predictability of a word carrying the message given a preceding word (i.e., $p(w_i|w_{i-1})$) and a following one (i.e., $p(w_i|w_{i+1})$). The following formulas represent these. Note that w_i is a word carrying a particular lexical message, w_{i-1} and w_{i+1} are a word preceding w_i and a word following w_i respectively, and *N* indicates "the number of." For example, *p*(penguin|blue) as $p(w_i|w_{i-1})$ can be calculated as the number of strings *blue penguin* divided by the number of strings of *blue*.

(2) Formula of lexical message predictability given preceding word and following word

$$p(w_i|w_{i-1}) = \frac{N(w_{i-1}w_i)}{N(w_{i-1})}$$

$$p(w_i|w_{i+1}) = \frac{N(w_i w_{i+1})}{N(w_{i+1})}$$

It has previously been demonstrated that a word is produced with shorter duration when the occurrence of the word is predictable given the context (i.e., the lexical message is predictable given the context). For example, Jurafsky et al. (2001) demonstrate that a word with higher predictability given the preceding word is produced with shorter duration than a word with lower predictability in spontaneous speech, and a word with higher predictability given the following word is produced with shorter duration than a word with lower predictability. In other words, redundancy in a signal correlates negatively with lexical message predictability.

Our theoretical framework, based on Exemplar Theory and MOP, can neatly account for probabilistic reduction depending on lexical message predictability. At the beginning of production, a speaker activates a particular lexical category that carries an intended lexical message, and chooses several exemplars belonging to the lexical category. During this process, a speaker could retrieve lexical message predictability on the basis of their exemplar space, which is formed by representing in memory previously encountered speech and may include information about how the particular word has been used in relation to other words. That is, $p(w_i|w_{i-1})$ and $p(w_i|w_{i+1})$ are retrievable from the exemplar space. After a production target is determined based on the chosen exemplars, the production target undergoes production biases (i.e., signal modification principle in (1)). If an intended lexical message is more predictable given the context, the speaker may decide to reduce redundancy in the production target; if an

intended lexical message is less predictable given the context, the speaker may decide to add more redundancy to the production target. The redundancy of a signal usually correlates with the duration of a signal positively (Aylett & Turk 2004; 2006; Levy & Jaeger 2007). Hence, a production target is produced with shorter duration when it receives smaller investment of resource cost. In this way, the investment of resource cost in a production target is a function of the message predictability retrieved from exemplar space, and the amount of resource cost is guided by articulatory biases (i.e., signal modification principle in (1)).

We aim to extend this prediction to social message predictability. Messages, as mentioned throughout this thesis, include not only lexical but also social information. Speakers convey their social properties through speech. As discussed above, the production of a loanword in NZE illustrates this, i.e., (3a) there are two variants, imported structure and adapted structure, carrying different social messages. That is, a speaker could express her intended social message by choosing imported structure or adapted structure. We assume that (1), in production of a loanword, a speaker activates a particular lexical category in accordance with her intended lexical message, and then activates adapted structure or imported structure to express a social message. Then, a production target is formed by (2a) choosing an exemplar belonging to the activated category and (2c) averaging the exemplar with the surrounding exemplars. During this process, a speaker could retrieve the probability of imported structure as opposed to adapted structure (0d) given a loanword and (0e) that given a speaker, based on the exemplar space. The formulas will be offered in the next section. It is hypothesized that (3c) these two types of selection predictability represent the social message predictability because a social message is always carried by a sociolinguistic variant and expressed by choosing a variant. On the basis of the signal modification principle in (1), we specifically hypothesize that (3b) speakers are more likely to decrease redundancy in a production target when its social message is more predictable given the context, and vice versa, see Figure 1.12. Finally, we hypothesize that (3d) the redundancy of imported structure (i.e., tap sounds) correlates with the duration (i.e., formant cessation), because formant cessation increases the signal specificity (i.e., differentiates further imported structure from adapted structure). On the basis of these hypotheses, the following prediction relevant to RQ6 can be deduced. This prediction is illustrated in Figure 6.2:

Prediction 6: Imported structure with lower information content (i.e., when a social message carried by imported structure is more predictable) given a loanword and given a speaker is more likely to have shorter duration (i.e., formant cessation), all else being equal.

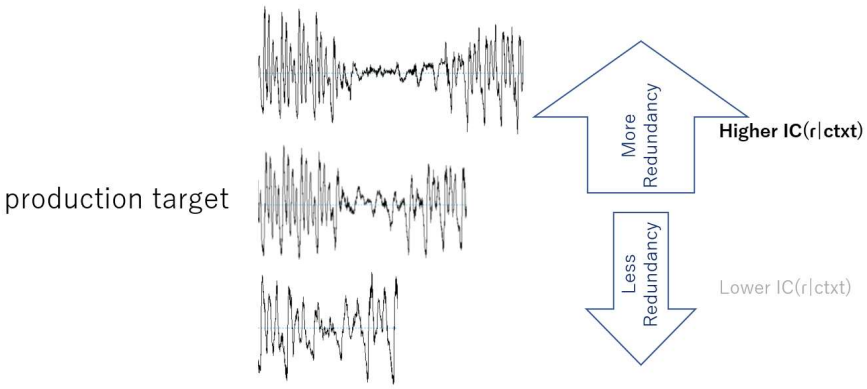

Figure 6.2 Message-based prediction for duration of imported structure

6.3 Methodology

This section illustrates the research design employed in the current chapter in order to assess the above prediction. In what follows, we will explain what kind of data is explored (6.3.1), how the predictability of imported structure given a loanword and a speaker is calculated (6.3.2), and how the duration of imported structure is measured (6.3.3).

6.3.1 Source of data

In order to test the above prediction, the dataset reported in the last three chapters is explored again. In the last three chapters, the likelihood of adaptation vs. importation was discussed, whereas in this chapter, the duration of imported structure is discussed. As explained in the following two sections, only acoustically identified imported structure (i.e., tokens with clear consonantal edges) will be examined.

As was discussed in the preceding three chapters, Experiments 1 and 3 employ a passage-reading task, while Experiment 2 employs a word-list reading task. Because of their different nature, we will discuss each type of task separately. That is, the data from Experiments 1 and 3 are statistically analysed alongside each other (Section 6.5), and the data from Experiment 2 is analysed separately (Section 6.4).

6.3.2 Calculation of predictability

The calculation of the social message predictability was performed on the dataset from the word-list reading task and that from the passage-reading task separately. As was discussed in 6.2, the predictability of the social message should be represented by the predictability of choosing the variant, because the social message is carried by a variant and expressed by choosing one of the two variants (adapted structure [ɪ] or imported structure [ɾ]). That is, the predictability of the social message carried by imported structure is defined as the selection predictability of imported structure [ɾ] as opposed to adapted structure [ɪ]. The context is a word and a speaker, as these contexts should be retrievable from mental representations, as discussed in 6.2. The formulas are as in (3). For example, the conditional probability of imported structure

given a *loanword*$_x$ can be calculated by dividing the number of *loanword*$_x$ produced with imported structure by the total number of productions of *loanword*$_x$.

(3) Formula for two types of importation predictability

$$p(imported\ structure|loanword_x) \approx \frac{N(imported\ structure\ \cap\ loanword_x)}{N(loanword_x)}$$

$$p(imported\ structure|speaker_x) \approx \frac{N(imported\ structure\ \cap\ speaker_x)}{N(speaker_x)}$$

For example, 41 tokens of *Timaru* were produced with adapted structure [ɹ] and 16 tokens of *Timaru* were produced with [ɾ] in the word-list reading task (Experiment 2). Then, the predictability of [ɾ] given *Timaru* is 28% (i.e., 16/57). In the same way, *p*(ɾ|koru) can be calculated as in the following table. *Speaker 6* produced 40 tokens with [ɹ] and 38 tokens with [ɾ]. Hence, the predictability of [ɾ] given *Speaker 6* is 49% (i.e., 38/78). Similarly, the predictability of [ɾ] given *Speaker 10* is 84% as in the following table:

Number of [ɹ] and [ɾ] given loanword			Number of [ɹ] and [ɾ] given speaker		
Loanword	N of [ɹ]	N of [ɾ]	Speaker	N of [ɹ]	N of [ɾ]
Timaru	41 (72%)	16 (28%)	*Speaker 6*	40 (51%)	38 (49%)
koru	14 (22%)	48 (78%)	*Speaker 10*	12 (16%)	63 (84%)

Table 6.1 Sample probabilities given loanword and speaker in Experiment 2

This raw probability was transformed into information content by taking $-\log_2$. For example, the information content given *Timaru* is 0.35 bits (i.e., $-\log_2(0.78)$). The information content was centred throughout the whole dataset. Centring is the rescaling of values by subtracting the mean, and it allow us to remove collinearity. Figure 6.3 illustrates how raw probability and information content are related in the word-list reading task. The left-hand figure indicates the predictability of [ɾ] given a loanword, and the right-hand figure shows us the predictability of [ɾ] given a speaker. Note that four speakers are removed from the right-hand figure, as they did not produce imported structure at all. The horizontal axis indicates raw probability, and the vertical axis indicates centred information content. As is clear, the raw probability and the centred information content negatively correlate, that is, lower probability results in higher information content. In the following statistical analyses, centred information content is employed rather than raw probability, because it is well-known that information content represents the amount of uncertainty of an event or a message better than raw probability (Shannon 1948; Goldsmith 2002; Hume & Mailhot 2013).

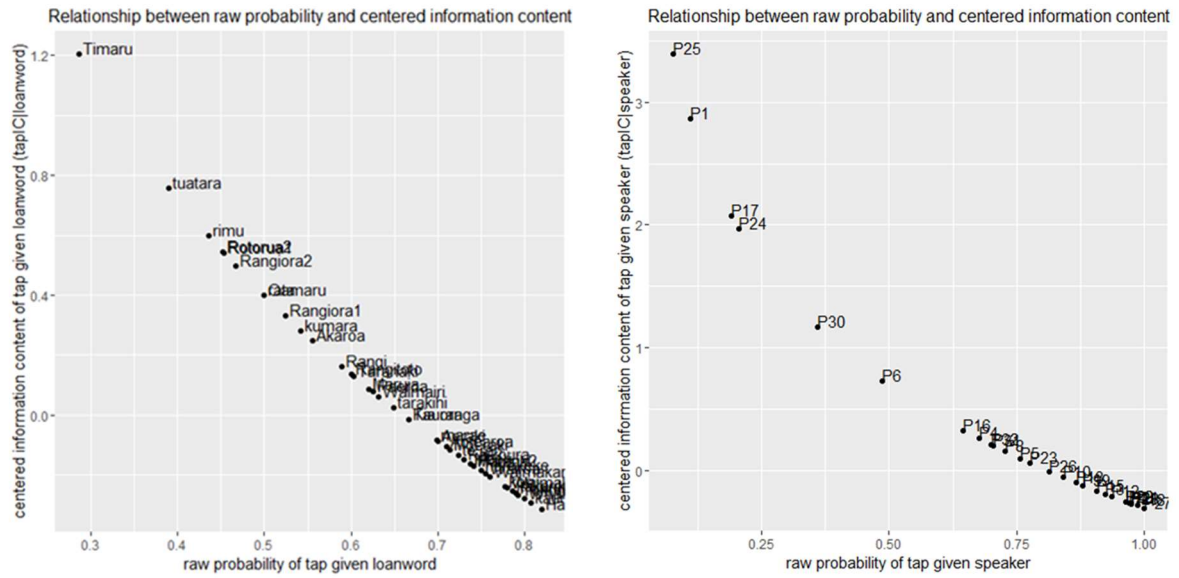

Figure 6.3 Relationship between raw probability and centred information content given loanword (left) and speaker (right) in word-list reading task (Experiment 2)

Separately from the word-list reading task, the two types of probability were calculated within the dataset of passage-reading tasks (Experiments 1 and 3). The calculation is the same as explained above. Raw probability was transformed into information content by taking $-\log_2$, and information content was centred for statistical reasons. Figure 6.4 indicates the relationship between raw probability and centred information content in the passage-reading task. The left-hand figure indicates the predictability of [ɾ] given a loanword, and the right-hand figure represents the predictability of [ɾ] given a speaker. (Note that fourteen speakers are removed from the right-hand figure, as they did not produce imported structure at all.) Once again, they negatively correlate, and the centred information content is employed in the following statistical analyses.

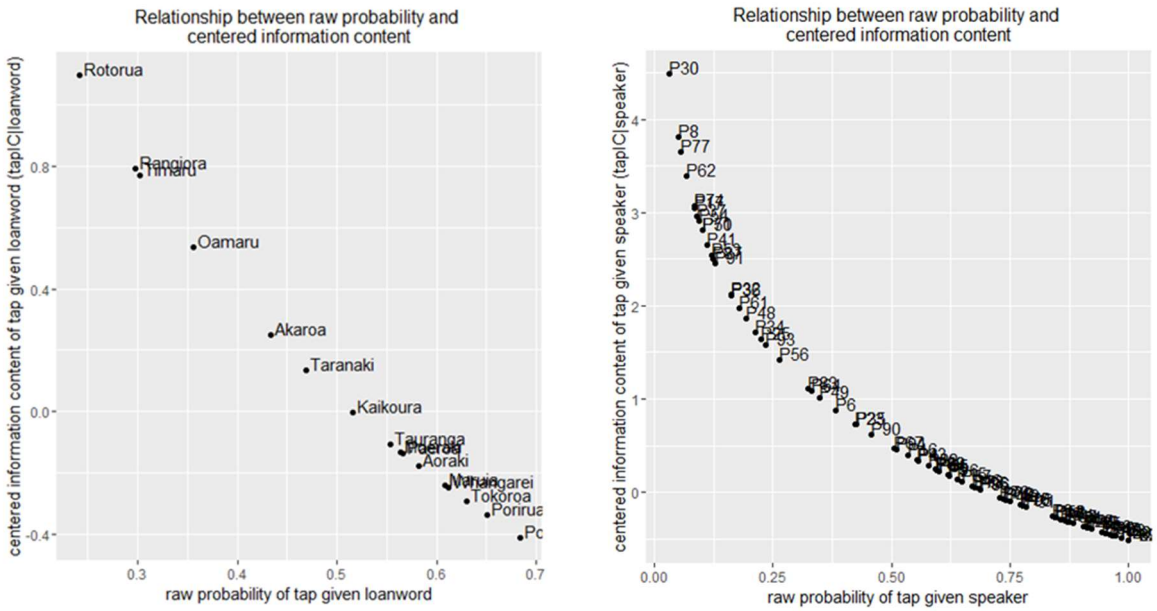

Figure 6.4 Relationship between raw probability and centred information content given loanword (left) and speaker (right) in passage reading task (Experiments 1 and 3)

6.3.3 Measurement of tap duration

As the duration of imported structure (i.e., tap sound [ɾ]) is discussed in this chapter, it is important to clarify how the duration was determined. In the majority of cases, the domain of tap sounds was determined with reference to the waveform. The onset of a tap was identified at the end of clear periodic waves (i.e., vocalic waves), and the end of a tap was identified at the start of clear periodic waves. This primary measurement criterion was developed on the basis of Foulkes et al. (2010). The sample annotation is shown in Figure 6.5.

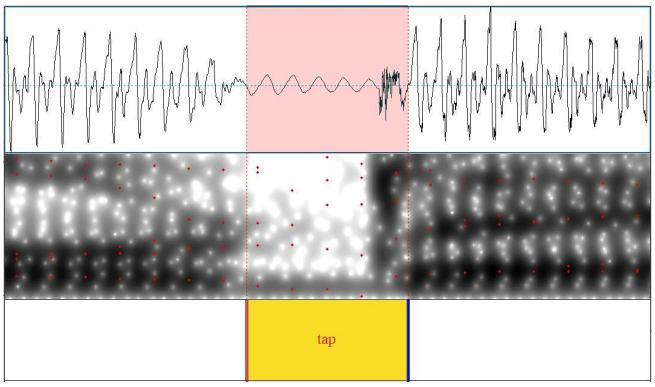

Figure 6.5 Domain of imported structure based on sound wave ("Moeraki" by P19)

In several cases, sound waves were not clear. Then, spectrographic information was used. The onset and the end of taps were identified as the end and the start of clear vowel formants. This secondary criterion was also based on Foulkes et al. (2010). The sample annotation is shown in Figure 6.6.

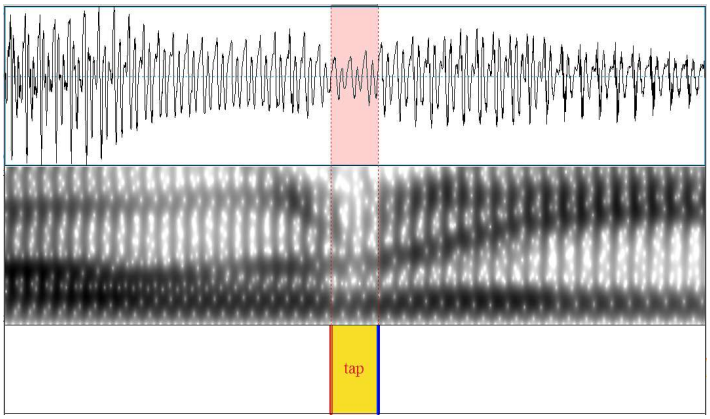

Figure 6.6 Domain of imported structure based on formant structure ("kauɾi" by P5)

In both cases, it was ensured using a Praat script that the measurements were taken at zero crossing (Ladefoged 2006).

6.4 Results: word-list reading task (Experiment 2)

In this section, we will illustrate the results of the word-list reading task in relation to the duration of imported structure, and show the statistical analyses.

6.4.1 Number of observations

As was discussed in Chapter 4, tokens identified as imported structure consist of acoustically identified tokens and impressionistically identified tokens. As the latter types of tokens are not clear in terms of their segmental domains, they are not included in the following statistical analysis. Hence, 1,372 acoustically identified tap sounds are analysed in what follows.

6.4.2 Variables

6.4.2.1 Response variable: duration of imported structure [ɾ]

The response variable is the log duration of imported structure. The measurement of raw duration is as explained above. The raw duration was transformed into log duration by taking the natural log, the default in R (R Core Team 2016). Figure 6.7 shows the density of the raw values and the log-transformed values. The mean of raw duration is 0.025 seconds, the median is 0.023, and the standard deviation is 0.008. The mean of log duration is −3.74, the median is −3.76, and the standard deviation is 0.32.

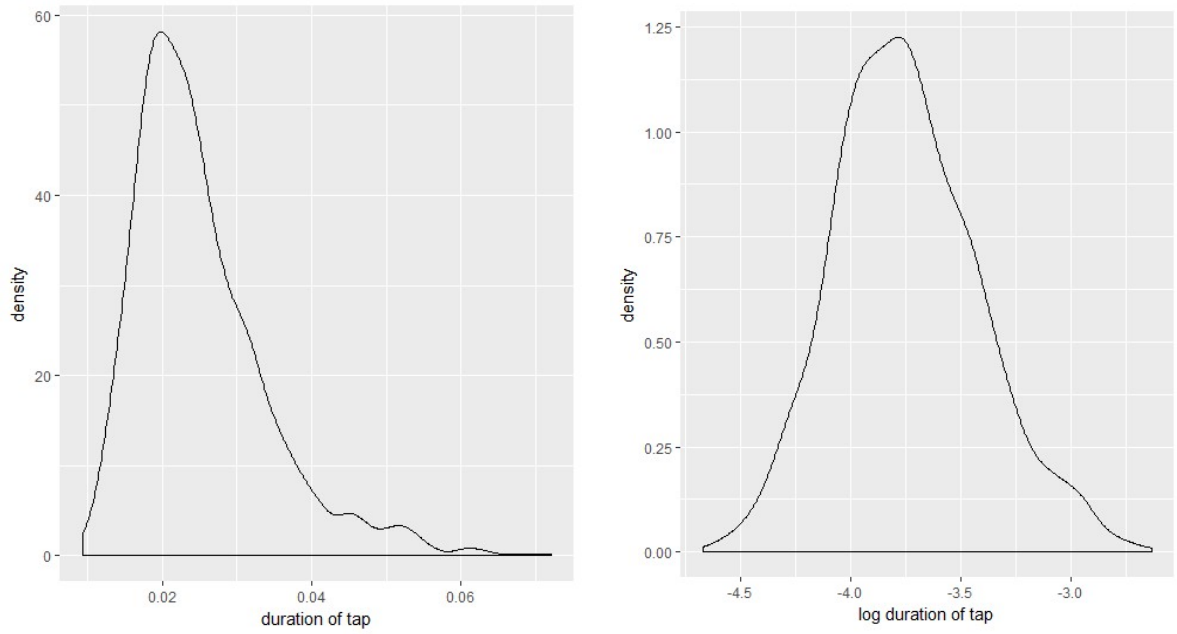

Figure 6.7 Density plot of raw duration (left) and log duration (right) of imported structure in word-list reading task (Experiment 2)

6.4.2.2 Key predictors: IC(ɾ|loanword) and IC(ɾ|speaker)

As discussed above, the variables of interest are two types of centred information content: *IC(ɾ|loanword)* and *IC(ɾ|speaker)*. These two variables were calculated from the two types of raw probabilities, *p*(ɾ|loanword) and *p*(ɾ|speaker), as discussed in the last section. These two variables are called *tapIC|loanword* and *tapIC|speaker* respectively in our data frame, and will be fitted in the following statistical analysis. The distribution is illustrated in Figure 6.3. Recall that there is a negative correlation between centered information content and raw probability, that is, the centered information content of imported structure is higher when the raw conditional probability of imported structure is lower, and vice versa.

6.4.2.3 Control variables

As with the last three chapters, we explore other variables as control variables. First, *position* in word is a variable that may highly affect the duration of a segment. It is well-known that word-initial segments are likely to be longer than word-medial segments (Lindblom 1968; Umeda 1977; Lavoie 2001). A word-initial /r/ is coded as word-initial (e.g., *r̲ata* and *r̲imu*), and a word-medial /r/ is coded as word-medial (e.g., *kor̲u* and *Timar̲u*) in our dataset.

Prosodic position may also affect the duration of segments. It is well-known that a segment preceding a main-stressed vowel is longer, and a segment following a main-stressed vowel is shorter (Umeda 1977; Cohen-Priva 2015). We annotated impressionistically these two prosodic features while taking intensity and pitch patterns in spectrograms into consideration. These are called *precSt* and *folSt*.

Speech rate may also affect the duration of segments. A segment is likely to be shorter in

faster speech (Byrd & Tan 1996). We calculated local speech rate. The local speech rate was calculated by the number of vocalic elements divided by the duration of a word minus the duration of imported structure (i.e., number of vocalic elements / (duration of a word – duration of [ɾ])). This represents number of vocalic elements per second, and it is expected that a segment is shorter when this value is higher. This variable is treated as *SpRate*.

NofSeg (number of segments) is another variable that may affect the duration of a segment. It is known that a segment in a longer word is more likely to be produced with shorter duration (Lindblom 1968). Hence, it can be expected that a tap sound is shorter, when it appears in a loanword with more segments.

It is also known that high frequency words are more likely to be reduced (Bybee 2001; Jurafsky et al. 2001), and a segment in a high frequency word may also be shorter (Cohen-Priva 2015). Hence, *subjFreq* (subjective word frequency) is expected to affect the duration of imported structure negatively.

Similarly, the pronunciation of a word may be reduced, as a word is mentioned twice or several times. Fowler & Housum (1987) demonstrate that the second mention of a word tends to be shorter in comparison to the first mention in natural speech. This effect is replicated in the lab by Baker & Bradlow (2009). As a participant completed the same task twice, *session* is also explored. A segment might be shorter at the second session than at the first session, because it is the second mention.

The other variables explored in Chapter 4 (*frame*, *PC-attitude*, *PC-culture*, *PC-people*, *wordMaoriness*, *speakerPlace*, and *wordType*) are also explored, even if they are not expected to affect the duration of a segment. All the variables examined in this section are listed in Table 6.2.

tapIC|loanword	Information content of imported structure given loanword (numeric)
tapIC|speaker	Information content of imported structure given speaker (numeric)
position	/r/ sound is word-initial vs. word-medial (binary)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)
SpRate	Number of vocalic elements per second within word (numeric)
NofSeg	Number of segments within a target loanword (numeric)
subjFreq	Subjective word frequency (numeric)
session	Pronounced in the first session (before a break) vs. the second (binary)
frame	Current presented cultural frame is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
wordType	Loanword is common noun vs. proper noun (binary)

Table 6.2 List of variables examined in statistical analyses

6.4.3 Linear regression analyses

The 1,372 tokens of acoustically identified [ɾ]-realizations were hand-fitted into a mixed-effects regression model with the *lmer* function in the *lme4* library (Bates et al. 2015) and *lmerTest* library (Kuznetsova et al. 2016) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 5 variables (*PC-attitude*, *PC-culture*, *PC-people*, *wordMaoriness*, and *speakerPlace*) were eliminated one-by-one through pairwise comparisons of models with and without each variable. As for these 5 variables, their interactions with the other variables were not examined, because their t-values were very low. Then, backward elimination was performed manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the remaining 11 variables (*tapIC|loanword*, *tapIC|speaker*, *position*, *precSt*, *folSt*, *SpRate*, *NofSeg*, *subjFreq*, *session*, *frame*, and *wordType*). The elimination was based on t-value, that is, either a single effect or an interaction with the lowest t-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was adopted. That is, factors that did not reach significance via model comparison were removed. Through this process, six factors (*tapIC|speaker*, *precSt, NofSeg, session, frame,* and *wordType*) were dropped. Finally, by-word random slopes for *SpRate* and by-speaker random slopes for *tapIC|loanword*, *position*, and *folSt* were added to the model, the result of which was that *subjFreq* was removed from the model. A Variance Inflation Factor (VIF) test was performed on the final model, and all VIF

scores were below 4, which suggest that there is no multicollinearity in the model. The other assumptions of linear models (linearity, homoskedasticity and normality of residuals) were also checked visually by inspecting a residual plot and a histogram of the residuals (see Winter 2013). The best-fitted model is shown in Table 6.3, with the reference levels being `position medial` and `folSt no`:

impDur ~ position+folSt+tapIC|loanword+SpRate

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-4.22130	0.11248	-37.529	< 2e-16	***
tapIC|loanword	0.14651	0.04960	2.954	0.005064	**
position initial	0.30220	0.03846	7.858	2.78e-11	***
folSt yes	0.08925	0.01839	4.854	1.46e-06	***
SpRate	-0.20344	0.05354	-3.800	0.000161	***

Table 6.3 Summary of best-fitted model for word-list reading task (Experiment 2)

The response variable is the log-transformed duration of imported structure. Positive coefficients indicate longer duration of imported structure, and negative coefficients indicate shorter duration of imported structure. As for the two variables of interest, only *tapIC|loanword* was found to be a significant predictor (β=0.14, t=2.95, p<0.01). This effect is in the predicted direction, that is, imported structure with higher information content (i.e., lower predictability) given a loanword is produced with longer duration. Figure 6.8 illustrates the effect of *tapIC|loanword* on the duration of imported structure. The horizontal axis indicates centred information content given loanword, and the vertical axis indicates the log duration of imported structure. The blue line represents a regression line, and the dots represent individual datapoints. Note that the horizontal axis corresponds with the vertical axis of Figure 6.3:

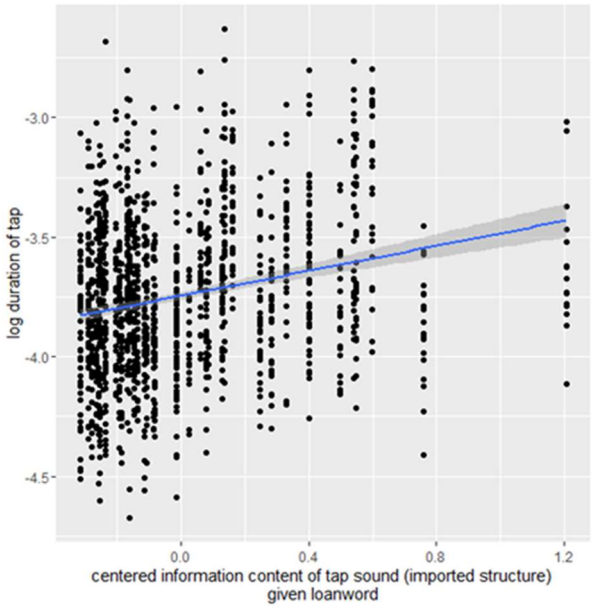

Figure 6.8 Scatter plot of relationship between *IC*(r|loanword) and log duration of tap

On the other hand, *tapIC|speaker* does not show significant effects on the duration of imported structure (p=0.44).

As for control variables, the three variables (*position*, *folSt*, and *SpRate*) corroborate previous findings, i.e., a segment at word-initial position is longer (β=0.3, t=7.85, p<0.001); a segment in a main-stressed syllable is longer (β=0.08, t=4.85, p<0.001); a segment is shorter in faster speech (β=−0.2, t=−3.8, p<0.001). On the other hand, we did not find significant effects of other four variables that could be expected to affect segmental duration according to previous literature: *precSt* (p=0.99), *NofSeg* (p=0.58), *subjFreq* (p=0.39) and *session* (p=0.45). The other control variables did not show any significant effects as expected. A summary of the findings is offered in Table 6.4.

tapIC|loanword	When a social message carried by imported structure is less predictable given a loanword, the duration of imported structure is shorter (p<0.01).
position	Imported structure is produced with longer duration at word-initial position (p<0.001).
folSt	Imported structure is produced with longer duration in a main-stressed syllable (p<0.001).
SpRate	Imported structure is produced with shorter duration in faster speech (p<0.001).

Table 6.4 Summary of finding in word-list reading task (Experiment 2)

6.5 Results: passage-reading task (Experiments 1 and 3)

In this section, we will illustrate the results of the passage-reading task in relation to the

duration of imported structure, and show the statistical analyses.

6.5.1 Number of observations

As in the preceding section, tokens identified as imported structure in the passage-reading task include impressionistically identified tokens. These tokens were excluded from the following statistical analyses as it is unclear where their domains are. 848 tokens of /r/-realizations were acoustically identified as taps in Experiment 1, whereas 3,072 tokens of /r/-realizations were acoustically identified as taps in Experiment 3. As a result, 3,920 tokens are examined in the following mixed-effects linear regression analysis.

6.5.2 Variables

6.5.2.1 Response variable: duration of imported structure [ɾ]

As with the last section, the response variable is the log-duration of imported structure. Figure 6.9 shows the raw value and the log-transformed value. The mean of raw duration is 0.024 seconds, the median is 0.022, and the standard deviation is 0.008. The mean of log duration is −3.77, the median is −3.77, and the standard deviation is 0.33. As shown in the figures, raw durations are slightly right-skewed, and the log-transformation remedies the skew. Note that the mean and the median are slightly shorter than those in a word-list reading task (see 6.4.2.1). This might be because passage-reading tasks allow participants to pronounce loanwords in a more natural way.

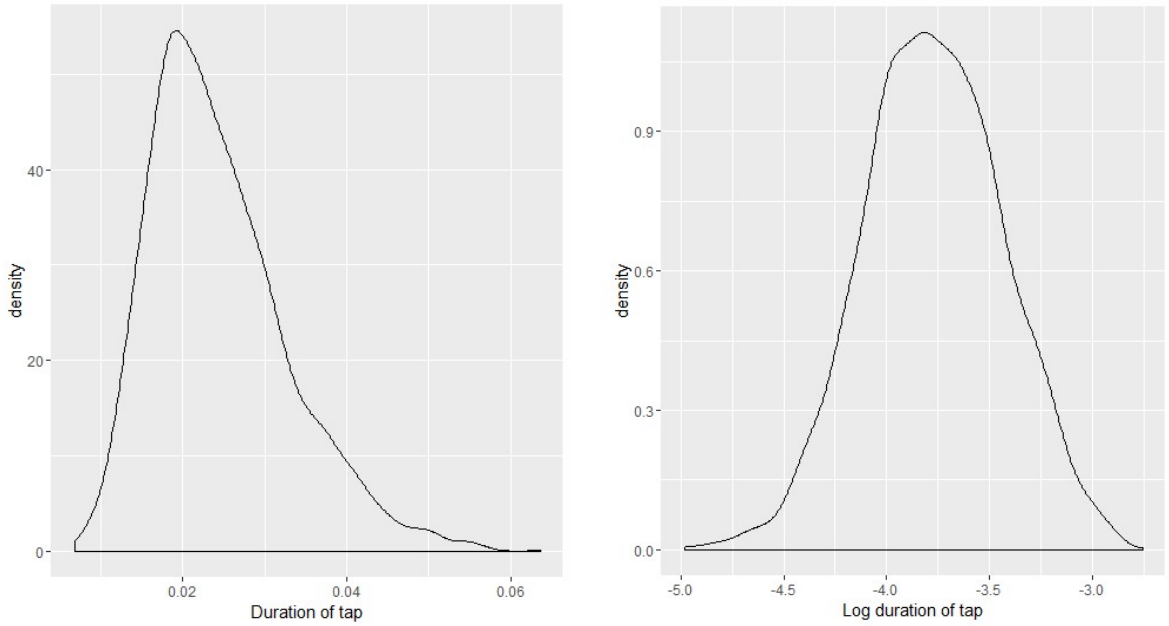

Figure 6.9 Density plot of raw duration (left) and log duration (right) of imported structure in passage reading task (Experiments 1 and 3)

6.5.2.2 Key predictors: IC(ɾ|loanword) and IC(ɾ|speaker)

As with the last section, the variables of interest are two types of centred information content: *IC(ɾ|loanword)* and *IC(ɾ|speaker)*. These are shown in Figure 6.4. These two variables are called *tapIC|loanword* and *tapIC|speaker* respectively in our data frame.

6.5.2.3 Control variables

For the same reasons as discussed in 6.4.2.3, the following variables are explored as control variables: *precSt*, *folSt*, *SpRate*, *NofSeg*, *subjFreq*, and *session*.

Because of the nature of a passage-reading task, effects of prosodic breaks (*precBr* and *folBr*) are also explored. We coded /r/ in a word preceding a prosodic break as *precBr=yes*, and that following a prosodic break as *folBr=yes*. In the current study, a prosodic break refers to a clear pause, which is considered as a boundary of an intonational phrase. It is known that a word is likely to be pronounced with longer duration, when it precedes and follows a prosodic break (see Turk (2012) and her citations).

In addition to local speech rate (*SpRate*), a wider speech rate is also explored (*PassageSpRate*). This speech rate was calculated by dividing the number of syllables within a passage by the duration of the passage. This variable is supposed to represent a wider range of speech rate.

As was discussed in 6.4.2.3, the number of times being mentioned may affect the duration of a segment. As a target loanword is mentioned twice within a passage, this variable is also explored, and coded as *mention*.

Finally, the other variables discussed in Chapter 3 (*topic*, *PC-attitude*, *PC-culture*, *PC-people*, *wordMaoriness*, *speakerPlace*, and *wordPlace*) were also explored, even if they were not expected to affect the duration of a segment. Table 6.5 lists all the variables explored in this section.

tapIC|loanword	Information content of imported structure given loanword (numeric)
tapIC|speaker	Information content of imported structure given speaker (numeric)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)
SpRate	Number of vocalic elements per second within word (numeric)
NofSeg	Number of segments within a target loanword (numeric)
subjFreq	Subjective word frequency (numeric)
session	The first session (before a break) vs. the second session (binary)
precBr	/r/ appears in a loanword preceding a prosodic break vs. not (binary)
folBr	/r/ appears in a loanword following a prosodic break vs. not (binary)
PassageSpRate	Number of syllables per second within passage (numeric)
mention	Mentioned first within a passage vs. second (binary)
topic	Reading passage is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
wordPlace	Place referred to by a target loanword is in the North Island vs. the South Island (binary)

Table 6.5 List of variables examined in statistical analyses

6.5.3 Linear regression analyses

The 3,920 tokens of acoustically identified [ɾ]-realizations were hand-fitted into a mixed-effects regression model with the *lmer* function in the *lme4* library (Bates et al. 2015) and *lmerTest* library (Kuznetsova et al. 2016) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 9 variables (*mention*, *precBr*, *precSt*, *subjFreq*, *wordMaoriness*, *PassageSpRate*, *PC-culture, PC-people,* and *speakerPlace*) were eliminated one-by-one through pairwise comparisons of models with and without each variable. As for these 9 variables, their interactions with the other variables were not examined, as their t-values were very low. Then, backward elimination was performed manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the remaining 10 variables (*tapIC|loanword*, *tapIC|speaker*, *NofSeg*, *PC-attitude*, *session*, *SpRate*, *wordPlace*, *folSt*, *folBr*, and *topic*). The elimination was based on t-value, that is, either a single effect or an interaction with the lowest t-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was adopted. That is, factors that did not reach significance via model

comparison were removed. Through this process, 5 variables (*tapIC|speaker*, *tapIC|loanword*, *NofSeg*, *session*, and *wordPlace*) were dropped. Finally, by-speaker random slopes for *folSt* and *topic* were added to the model, as they improved the model. The ANOVA comparison was performed until all remaining predictors show significance, and consequently, *topic* was removed from the model. A Variance Inflation Factor (VIF) test was performed on the final model, and all VIF scores were below 4, which suggest that there is no multicollinearity in the model. The other assumptions of linear models (linearity, homoskedasticity and normality of residuals) were also checked visually by inspecting a residual plot and a histogram of the residuals (see Winter 2013). The best-fitted model is as in Table 6.6 with the reference levels being `folSt no` and `folBr no`:

impDur~SpRate+folSt+folBr+PC-attitude

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-4.11281	0.07987	-51.494	< 2e-16	***
SpRate	-0.15306	0.03516	-4.354	1.37e-05	***
folSt yes	0.05099	0.01458	3.498	0.000718	***
folBr yes	0.03566	0.01421	2.509	0.012139	*
PC-attitude	0.03995	0.01809	2.208	0.030045	*

Table 6.6 Summary of best-fitted model for passage reading task (Experiments 1 and 3)

As with the last section, positive coefficients indicate longer duration of imported structure, and negative coefficients indicate shorter duration of imported structure. The two variables of interest neither achieve a sufficiently significant level (p<0.05). As with the result from the word-list reading task, *tapIC|speaker* was not significant at all (p=0.76). On the other hand, *tapIC|loanword* shows a trend in the predicted direction (p=0.09). The scatter plot (Figure 6.10) illustrates this trend. The vertical axis shows the log duration of tap sounds and the horizontal axis shows the information content of imported structure given a loanword. The blue line represents a regression line, and the dots represent individual datapoints. Note that the horizontal axis corresponds with the vertical axis in Figure 6.4. There is a slight tendency that imported structure is produced with longer duration when the information content given a loanword is higher, that is, the predictability given a loanword is lower:

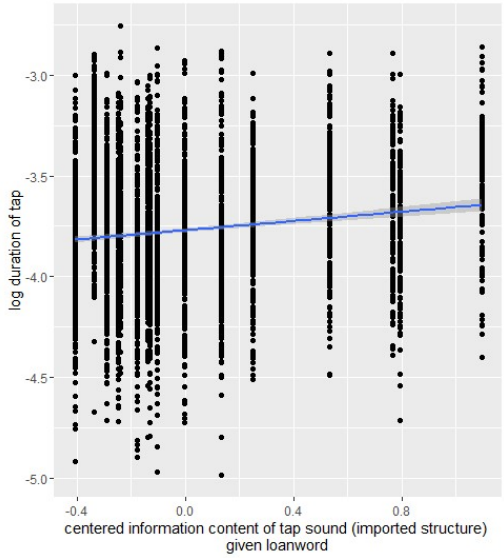

Figure 6.10 Scatter plot of relationship between *IC*(r|loanword) and log duration of tap

As for control variables, the three variables (*SpRate*, *folSt*, and *folBr*) corroborate the previous findings, i.e., a segment is shorter in faster speech (β=−0.15, t=−4.3, p<0.001); a segment in a main-stressed syllable is longer (β=0.05, t=3.49, p<0.001); a segment in a word preceding a prosodic break is longer (β=0.03, t=2.5, p<0.05). On the other hand, we did not find significant effects of other seven variables that could be expected to affect segmental duration according to previous literature: *precSt* (p=0.48), *NofSeg* (p=0.41), *subjFreq* (p=0.7), *precBr* (p=0.79), *PassageSpRate* (p=0.41), *mention* (p=0.28), and *session* (p=0.2).

As for the other control variables, *PC-attitude* shows a significant effect. This suggests that borrowers with more positive attitudes towards Māori are more likely to produce imported structure with longer duration (β=0.03, t=2.2, p<0.05). In addition, *topic* shows a trend, although it did not achieve a sufficiently significant level (p=0.07). This variable suggests that imported structure is more likely to be produced with longer duration when a passage is about Māori. The other control variables did not show any significant effects as expected.

Table 6.7 summarizes the findings by exploring the dataset collected from the passage-reading task. Variables showing trends are shaded in Table 6.7.

tapIC|loanword	When a social message carried by imported structure is less predictable given a loanword, the duration of imported structure is shorter (p=0.09)
SpRate	Imported structure is produced with shorter duration in faster speech (p<0.001).
folSt	Imported structure is produced with longer duration in a main-stressed syllable (p<0.001).
folBr	Imported structure is produced with longer duration when the loanword precedes a prosodic break (p<0.05).
PC-attitude	Imported structure is produced with longer duration by speakers with more positive attitudes towards Māori (p<0.05).
topic	Imported structure is produced with longer duration in passages about Māori (p=0.07).

Table 6.7 Summary of finding in passage-reading task (Experiments 1 and 3)

6.6 Discussion

Let us now discuss the statistical results in relation to the hypotheses presented in 6.2. As was reviewed above, previous literature has demonstrated that the duration of a segment is determined by a variety of factors such as prosodic factors, usage factors, and predictability effects. It was found that this is true in the production of imported structure in loanwords. In the word-list reading task, *position*, *folSt*, and *SpRate* showed significant effects on the duration of tap sounds, and in the passage-reading task, *SpRate*, *folSt*, and *folBr* showed significant effects on the duration of tap sounds. The direction is as discussed in the preceding sections, and it is in line with the previous literature.

On the other hand, we did not find significant effects of some control variables that were expected to affect the duration of imported structure. First, the number of segments (*NofSeg*) was not a significant predictor. This might be because most of the loanwords employed in the current study are long words, and many of them are trisyllabic or quadrisyllabic. The current study does not examine monosyllabic words. Lindblom (1968) shows that the difference in segmental duration is large between monosyllabic words and disyllabic words, but the difference is smaller or none between multiple-syllable words (i.e., disyllabic vs. trisyllabic and trisyllabic vs. quadrisyllabic). Next, the effect of *passageSpRate* is not significant in the current study. The reason might be that pauses were not taken into consideration in the measurement, and it may not exactly index speech rate at a passage level. It was calculated by dividing the number of syllables by the overall duration of a passage including pauses. As for *precBr*, it was not significant. The reason might be because only word-medial tap sounds were examined in the passage-reading task. Turk (2012) notes that final lengthening can target multiple syllables, whereas initial lengthening targets only the initial segment in the word. That is, no significant effects of *precBr* on word-medial tap duration actually corroborates her claim. The effect of

subjFreq was not significant in our data. This might be because subjective word frequency was explored rather than objective word frequency in the current study. In addition, the effect of word frequency on segmental duration is a topic of debate, as some previous studies found that segmental duration is not affected by word frequency (Warner & Tucker 2010; Bouavichith & Davidson 2013). Our result is consistent with their findings. Finally, the effect of repetition (*mention* and *session*) was not observed in our dataset. This null result might be the most difficult to account for in the current study. We could speculate that the repetition is likely to affect the duration of a vowel but it is unlikely to affect that of a consonant, because a consonant is inherently shorter than a vowel. This is left for future study.

In what follows, we will discuss the variables of interest, *tapIC|speaker* and *tapIC|loanword*, in more detail. In addition, we will discuss two sociolinguistic variables (*PC-attitude* and *topic*) that seem to affect the duration of imported structure in the passage-reading task. These discussions allow us to develop our understanding of how production of imported structure is guided by the message-oriented articulatory biases in relation to social message predictability.

6.6.1 Predictability given loanword

One of the key variables discussed in this chapter is $p(\text{ɾ}|\text{loanword})$, which is transformed into centred $IC(\text{ɾ}|\text{loanword})$ in the statistical analysis. The effect of this variable is statistically significant in the word-list reading task (β=0.14, t=2.95, p<0.01), whereas it trends in the passage-reading task (p=0.09). The reason for this difference might be that the word-list reading task employs a larger set of loanwords than the passage reading task, as the former task explored the pronunciation of 36 Māori loanwords while the latter task explored that of only 14 Māori loanwords. In addition, the word set employed in the word-list reading task included common nouns as well as place names, whereas the passage-reading task included only place names. The wider set of words might enable us to explore a variety of values of the predictability given a loanword, the result of which is that this variable showed a statistically significant effect in the word-list reading task. The direction of this predictability effect is as expected in 6.2: [Prediction 6] imported structure is produced with shorter duration when the selection of imported structure as opposed to adapted structure is more predictable given a loanword; that is, the social message carried by imported structure is more predictable. This result is consistent with previous findings about lexical message predictability, see 1.4 and 6.2.

This effect can be captured neatly in our theoretical framework. The current study assumes that linguistic knowledge is built by representing in memory tokens of previously encountered speech as exemplars. Exemplars with similar linguistic properties cluster together, and a phonological category (i.e., allophone, phoneme) and a lexical category (i.e., lexeme, word) are formed. At the beginning of production, a speaker activates a particular lexical category that carries an intended lexical message. In the production of a Māori loanword, a speaker chooses one of the two variants (i.e., imported structure vs. adapted structure), which are associated with

the Māori lexical category, to express a social message. During this process, a speaker could retrieve social message predictability based on the rate of exemplars of the lexical category (i.e., loanword) with imported structure and those with adapted structure. The higher the rate of imported structure is associated with a lexical category, the higher the predictability of the social message carried by imported structure is given to the loanword. After the production target is determined by choosing and averaging exemplars (see 1.7.3), it is influenced by production biases (see signal modification principle in (1)). Consequently, redundancy is reduced in the production target if the retrieved social message predictability is higher given the loanword, and vice versa. In other words, a speaker reduces resource cost in the production of a signal conveying a predictable social message given a loanword, thereby increasing the efficiency; a speaker increases the potential accuracy of a less predictable message transmission by improving the signal specificity, thereby increasing accuracy. Given our assumption that the redundancy in imported structure positively correlates with the duration of the structure (i.e., longer formant cessation increases the signal specificity of imported structure [ɾ]), imported structure is produced with shorter duration when it is more predictable given the loanword. This is illustrated in Figure 6.11 in relation to formula in (5) in Chapter 1. Provided that a social message is more predictable given a loanword, signal specificity could be low to reach a sufficiently high probability of accuracy; given that a social message is less predictable, signal specificity needs to be high to reach a high enough probability.

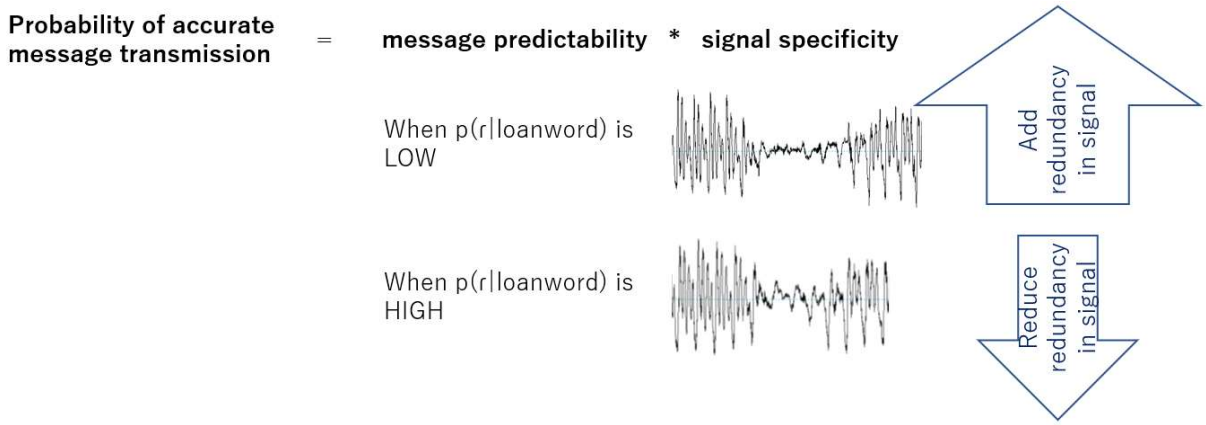

Figure 6.11 Signal specificity as a function of message predictability

In sum, the results discussed in this section support the hypotheses about the representation of probability (0d) and those about message-oriented modification (3a, 3b, 3c, 3d), see 1.7 and 6.2. These will be discussed in Chapter 8, along with the other chapter's findings.

6.6.2 Predictability given speaker

On the other hand, we did not find a significant effect of the other key variable *p*(ɾ|speaker), transformed into centred *IC*(ɾ|speaker) in the statistical analyses. The effect is neither significant in the word-list reading task (p=0.44) nor in the passage-reading task (p=0.76).

The possible reason may be that this type of predictability is more difficult for a speaker to retrieve. As is illustrated in Figure 6.1, the predictability of imported structure given a loanword could be retrieved by calculating the number of exemplars with imported structure and adapted structure associated with the lexical category. On the other hand, the predictability given a speaker would need to be retrieved by taking into account the overall number of exemplars with imported structure and adapted structure within the whole cognitive system (hypothesis 0e). That is, the predictability given a speaker could be calculated on the basis of the larger number of exemplars in comparison to the predictability given a loanword. A calculation based on a larger number of exemplars might be more difficult than one based on a smaller number of exemplars. Support for this hypothesis comes from a psychological study demonstrating that it is more difficult to count a larger number of dots displayed on a computer screen (Logie et al. 1986). Due to the difficulty of retrieving the predictability given a speaker, speakers might not be able to change the redundancy in a production target depending on this predictability. This implies that the hypothesis (0e) might be tentative and needs to be discarded. Further exploration will be left for future study.

6.6.3 Sociolinguistic variables: PC-attitude and topic

Finally, we would like to discuss two sociolinguistic variables, *PC-attitude* (attitude towards Māori) and *topic*. The variable *PC-attitude* was significant ($p<0.05$) in the passage-reading tasks, and the variable *topic* shows a trend ($p=0.07$). The significant effect of *PC-attitude* suggests that speakers with more positive attitudes towards Māori produce imported structure with longer duration; the trend showed by *topic* suggests that imported structure might be produced with longer duration in Māori passages.

This is worth commenting on, because these results seem to be inconsistent with the prediction derived from the message-oriented production biases. As was seen in Chapters 3-5, speakers with more positive attitudes towards Māori are more likely to produce imported structure. Chapters 3 and 5 also demonstrated that imported structure is more likely to be produced in Māori passages. That is, the production of imported structure is more predictable given a speaker with higher PC-attitude and a Māori topic. In other words, a social message carried by imported structure is more likely to be expressed given these two contexts (i.e., Māori topic and speakers with positive attitudes). Hence, our theoretical framework should deduce predictions that are opposite from what was uncovered about these two variables in this chapter.

One possible account is that a speaker might emphasize a signal for her intended social message when she wishes to express the message strongly. A speaker with more positive attitudes towards Māori might wish to express her solidarity with Māori strongly, and a speaker might wish to express her association strongly when reading a Māori passage. These speculations might be in line with Audience Design (Bell 1984; 2001), which hypothesizes that a speaker stylizes a linguistic feature in accordance with her intended social message. In order to clearly express the social message associated with Māori, a speaker might invest more

resource cost in the signal [ɾ] and improve the signal specificity, with the result that the signal is hyper-articulated and the formant cessation of [ɾ] becomes longer. In other words, when a speaker wishes to express the social message associated with Māori more accurately, the speaker adds redundancy to a signal to improve the signal specificity; when a speaker does not wish so strongly, the speaker reduces resource cost in the production of a signal, thereby increasing the efficiency. This account is illustrated in Figure 6.12 in relation to formula in (5) in Chapter 1. Given that a speaker strongly wishes to express her solidarity with Māori, the threshold at which accuracy becomes probable goes up, and accordingly signal specificity needs to be higher; provided that a speaker weakly wishes to express her association with Māori, the sufficiently high probability of accuracy is not so high, and accordingly signal specificity could be low.

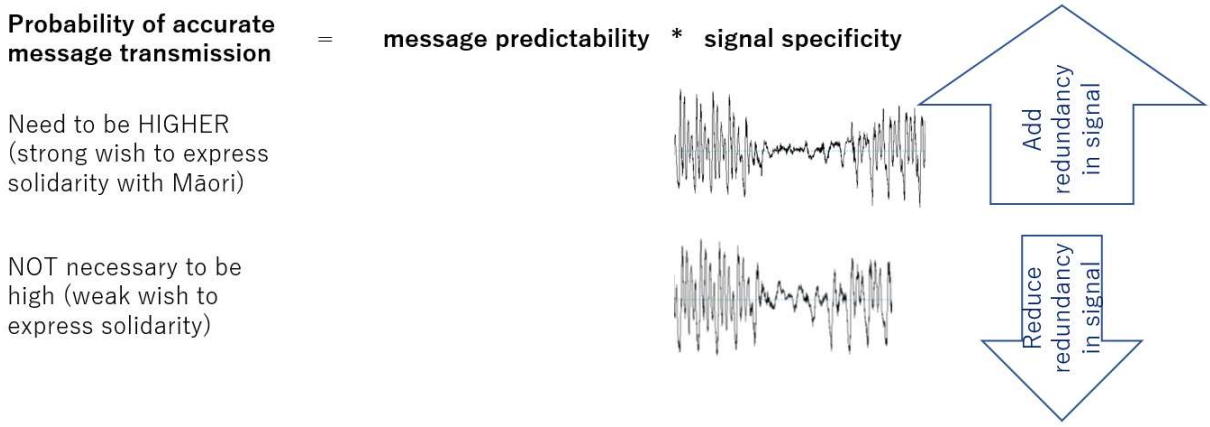

Figure 6.12 Signal specificity as a function of desired probability of accuracy

6.7 Summary

Finally, we will summarize this chapter. We explored the phonetic implementation of imported structure in this chapter. More specifically, we assessed [Prediction 6] that the redundancy in imported structure [ɾ] is influenced by social message predictability. The variables of interest are two types of predictability, *p*(ɾ|loanword) and *p*(ɾ|speaker), which were transformed into centred information content by use of statistical analyses. It was found that the effect of *p*(ɾ|loanword) is robust in the predicted direction. That is, redundancy is reduced from a signal when the social message is more predictable given a loanword. This would suggest that probabilistic reduction is not limited to lexical message predictability as has been demonstrated in previous literature, but it is also caused by social message predictability. It was demonstrated that this probabilistic reduction can be neatly captured by articulatory biases based on MOP (Hall et al. 2016; 2018), which hypothesizes that speakers balance resource cost and message transmission accuracy. On the other hand, *p*(ɾ|speaker) is not statistically significant. We speculated that the reason might be that this predictability is more difficult for a speaker to retrieve, because a speaker needs to count the larger number of exemplars in the whole cognitive system. In this way, the current chapter tests the hypotheses about (0) predictability

representation and (3) articulatory biases in our theoretical framework, and informs our understanding on how imported structure is processed in accordance with the social message predictability. This theoretical finding in the current chapter will be discussed in the final chapter, coupled with the finding in the next chapter.

Discussion about redundancy in imported structure in this chapter raises the question of whether redundancy in adapted structure [ɹ] is also influenced by the social message predictability. In the next chapter, we will address this question. As was clarified in Chapter 1, the degree of lowering F3 is regarded as redundancy in adapted structure, because a lower F3 value differentiates further adapted structure from imported structure [ɾ], that is, it improves the signal specificity of adapted structure. We will discuss the relationship between the F3 of [ɹ] and the predictability of choosing this structure as opposed to imported structure [ɾ] given a loanword and given a speaker.

Chapter 7 Phonetic implementation of loanword II: Redundancy in adapted structure [ɻ]

7.1 Introduction

The last chapter and the current chapter examine phonetic aspects of the production of loanwords, and address the research question [RQ1b]: *to what extent is the production of a variant in loanword phonology affected by the predictability of the social message*. Chapter 6 explored phonetic redundancy in the imported structure [ɾ], while this chapter examines redundancy in the adapted structure [ɻ]. The specific research question is as follows:

(1) Research question addressed in this chapter
RQ7: "Is the F3 of adapted structure affected by the predictability of the social message (i.e., the selection predictability of the adapted structure)?"

This question allows us to increase our understanding of how adapted structure is processed in loanword production [RQ1]. In particular, we can test the hypotheses regarding (0) predictability representation and (3) articulatory biases in our theoretical framework (see 1.7).

As discussed in Chapter 1 and the previous chapter, the effect of lexical message predictability is well-explored in the literature, but little, if anything, is known about the effect of social message predictability on redundancy in a variant of sociolinguistically meaningful variation. As with the preceding chapter, the current chapter aims to develop our understanding of the relationship between the realization of a linguistic unit and the predictability of the message.

This chapter consists of six sections. Section 7.2 reviews the hypotheses in our theoretical framework relevant to the current research question. Section 7.3 outlines the methodology to address the question. Section 7.4 reports the result of the statistical analyses, and Section 7.5 discusses the result. In the discussion, we will point out that the message-oriented account cannot capture the result reported in this chapter, and offer an alternative account based on an exemplar-averaging mechanism. It will be speculated that adapted structure caries a weak or neutral social message, and thus the effects of the message-oriented biases are concealed by the averaging mechanism, with more detail in 7.5.3. Section 7.6 summarizes this chapter.

7.2 Background

7.2.1 Theoretical framework: probability and articulatory biases

First, let us review some important parts of our theoretical framework relevant to the above research question. As this chapter explores the other aspect of redundancy in the production of loanwords, the key hypotheses which construct our theoretical framework are the same as those

discussed in the last chapter. We hypothesized in Chapter 1 that the predictability of adapted structure, that is the approximant [ɹ], is retrievable from exemplar space, the production target is determined on the basis of chosen exemplars, and the redundancy in the production target is reduced or increased in accordance with articulatory biases. More specifically, the following hypotheses and assumptions are relevant for this chapter.

(2) Relevant hypotheses and assumptions

(0d) The probability of adapted structure and imported structure given a loanword is represented in the mind of a NZE speaker, and it can be retrieved based on the number of exemplars with adapted structure and imported structure associated with a particular lexical category.

(0e) The probability of adapted structure and imported structure given a speaker is also represented in the mind of the NZE speaker, and it can be retrieved based on the number of exemplars with adapted structure and imported structure within the cognitive system of a particular speaker.

(2a) An exemplar is chosen in accordance with the category selected during category activation (1).

(2c) Several adjacent exemplars around the chosen exemplar are also picked up, and the average phonetic value of the chosen exemplars becomes a production target.

(3a) Variability between adapted and imported structures is sociolinguistically meaningful, with the structures carrying different social messages.

(3b) Speakers are more likely to add redundancy to a production target when its social message is less predictable given the context, and vice versa.

(3c) The predictability of the social message carried by adapted structure is defined as the selection predictability of adapted structure [ɹ] as opposed to imported structure [ɾ] given a context.

In addition to the above, we hypothesize that (3d) the redundancy of adapted structure correlates with the degree of lowering F3; that is, the specificity of the signal carrying adapted structure [ɹ] can be increased by lowering the F3 value. F3 is used as the relevant formant property since it is known that the rhotic's F3 is relatively lower in comparison to other approximant sounds (Lindau 1985; Olive et al. 1993: 7.3; Ladefoged 2006: 196; Hay & Maclagan 2010; Johnson 2011: 140 among others). As discussed in 1.7.4, lowering F3 differentiates the adapted structure [ɹ] further from the imported structure [ɾ] because the F3-lowering is characteristic of an approximant while formant interruption occurs in a tap sound (see Figure 1.13), that is, it is a key cue to identifying [ɹ]. Furthermore, we assume that lowering F3 incurs resource cost because it requires additional articulatory effort such as tongue bunching (i.e., retroflexion), lip rounding, and pharyngeal constriction (Olive et al. 1993: 7.3; Johnson 2011: 140). In this way, the additional articulatory gesture(s) needed to further lower

F3 of the adapted structure increases signal specificity and the probability that the social message will be accurately conveyed. Hence, it is plausible to regard the degree of F3-lowering as redundancy in adapted structure [ɹ].

7.2.2 Predictions

As clarified above, this chapter aims to test whether redundancy in adapted structure is affected by the social message predictability. In this section, we will deduce the prediction in relation to this research question on the basis of our theoretical framework. In Chapters 3-5, we argued that (3a) two variants, imported structure and adapted structure, carry different social messages. More specifically, NZE speakers can express social messages dissociated from Māori by choosing adapted structure as opposed to imported structure. We assume that (1), in the production of a loanword, a speaker activates a particular lexical category in accordance with her intended lexical message, and then activates adapted structure or imported structure to express a social message. Then, a production target is formed by (2a) choosing an exemplar belonging to the activated category and (2c) averaging the exemplar with the surrounding exemplars. During this process, a speaker could retrieve (0d) the probability of adapted structure as opposed to imported structure given a loanword and (0e) the probability of adapted structure as opposed to imported structure given a speaker, based on the exemplar space. It is hypothesized that (3c) these two types of selection probability represent the predictability of the social message carried by adapted structure, because the social message is expressed by choosing adapted structure against imported structure. The formulas will be explicitly defined in 7.3.2. We hypothesized that (3b) speakers are more likely to decrease redundancy in a production target when its social message is more predictable given the context, and vice versa. This is based on the signal modification principle, formulated in (6) in Chapter 1 (see Figure 1.12). Finally, we hypothesize that (3d) the redundancy in adapted structure [ɹ] negatively correlates with the value of F3, and lower F3 values increase the signal specificity of the social message carried by adapted structure. On the basis of these hypotheses, the following prediction relevant to RQ7 can be deduced.

Prediction 7: Adapted structure with *lower information content* (i.e., a social message carried by adapted structure is *more predictable*) given a loanword and given a speaker is more likely to be pronounced with *higher F3*, all else being equal.

This prediction is illustrated in Figure 7.1. The x-axis indicates the proportion of an approximant, and the y-axis indicates the F3 value. That is, this figure represents hypothetical formant transition patterns in accordance with the information content. The formant value of adapted structure with higher information content (i.e., lower predictability) is expected to drop further.

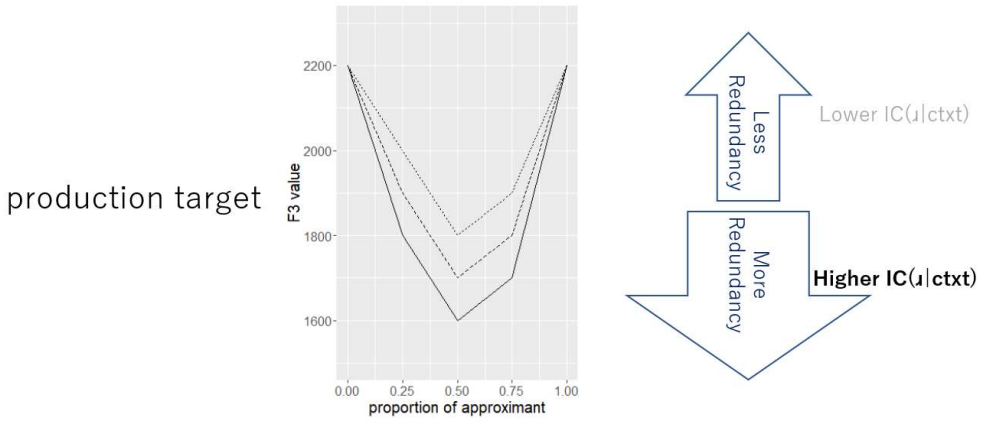

Figure 7.1 Message-based prediction for F3 value of adapted structure

7.3 Methodology

This section illustrates the research design employed in the current chapter in order to assess the above prediction. In what follows, we will explain what sort of data is discussed (7.3.1), how the predictability of adapted structure given a loanword and a speaker is calculated (7.3.2), and how the F3 value of adapted structure is measured (7.3.3).

7.3.1 Source of data

As with the previous chapter, the current chapter explores the data analysed to study the likelihood of adaptation vs. importation in Chapters 3-5. However, we do not statistically analyse and discuss the data collected from the word-list reading task (Experiment 2) because of the small number of /r/ realizations as adapted structure [ɹ]. As was discussed in 4.5, participants were more likely to produce imported structure in the word-list reading task, the result of which is that only 774 tokens were acoustically identified as approximants. It might not be suitable to perform statistical analyses on the small number of observations. On the other hand, statistical analyses are performed on the data collected from the passage-reading tasks (Experiments 1 and 3), given a larger number of tokens acoustically identified as approximants than the word-list reading task. 904 tokens were acoustically identified as approximants in Experiment 1, whereas 3,570 tokens were acoustically identified as approximants in Experiment 3, and consequently 4,474 tokens were collected from the passage-reading tasks.

7.3.2 Calculation of predictability

As was discussed in the preceding chapter, the social message predictability is defined as the predictability of choosing from a set of possible socially meaningful variants, a variant that carries a particular social message. In the production of Māori loanwords, a social message can be expressed by choosing the adapted structure [ɹ] or the imported structure [ɾ]. Social message predictability is therefore defined as the predictability of selecting a particular variant. As was hypothesized in the last chapter, the context is a word and a speaker, because the two contexts should be retrievable from exemplar space, with more detail in 1.7.1 and 6.2. The formulas of

the predictability of a social message carried by adapted structure are as in (3).

(3) Formula for two types of adaptation predictability

$$p(adapted\ structure|loanword_x) \approx \frac{N(adapted\ structure\ \cap\ loanword_x)}{N(loanword_x)}$$

$$p(adapted\ structure|speaker_x) \approx \frac{N(adapted\ structure\ \cap\ speaker_x)}{N(speaker_x)}$$

Table 7.1 illustrates how these two types of predictability are calculated using the dataset from the passage-reading tasks (Experiments 1 and 3). For instance, 208 tokens of *Tokoroa* were produced with adapted structure, and 355 tokens of *Tokoroa* were produced with imported structure in the passage-reading tasks (Experiments 1 and 3). Hence, the probability of [ɹ] given *Tokoroa* is 36.9% (i.e., 208/563). Similarly, *p(adapted structure|Timaru)* can be calculated as in Table 7.1. *Speaker 81* produced 13 tokens with adapted structure and 98 tokens with imported structure in the passage-reading task. In this case, the probability of [ɹ] given this speaker is 11.7% (i.e., 13/111). In the same way, *p(adapted structure|Speaker 81)* can be calculated as in Table 7.1.

Number of [ɹ] and [ɾ] given loanword			Number of [ɹ] and [ɾ] given speaker		
Loanword	N of [ɹ]	N of [ɾ]	Speaker	N of [ɹ]	N of [ɾ]
Tokoroa	208 (36.9%)	355 (63.1%)	*Speaker 81*	13 (11.7%)	98 (88.3%)
Timaru	443 (69.7%)	192 (30.3%)	*Speaker 90*	68 (54.4%)	57 (45.6%)

Table 7.1 Sample probabilities given loanword and speaker in Experiments 1 and 3

As in the last chapter, this raw probability was transformed into information content by taking $-\log_2$, and the information content was centred throughout the whole dataset. Recall that centring is the rescaling of values by subtracting the mean, and allow us to remove collinearity. Figure 7.2 illustrates how raw probability and centred information content are related. The left-hand figure indicates the predictability of [ɹ] given a loanword, and the right-hand figure shows the predictability of [ɹ] given a speaker in the passage-reading tasks. (Note that three speakers are removed from the right-hand figure, as they did not produce adapted structure at all.) The horizontal axis indicates raw probability, and the vertical axis indicates centred information content. As is clear, the raw probability and the centred information content negatively correlate, that is, lower probability results in higher information content. In the following statistical analyses, centred information content is employed rather than raw probability, because information content is known to represent the degree of uncertainty of an event or a message better than raw probability (Shannon 1948; Goldsmith 2002; Hume & Mailhot 2013).

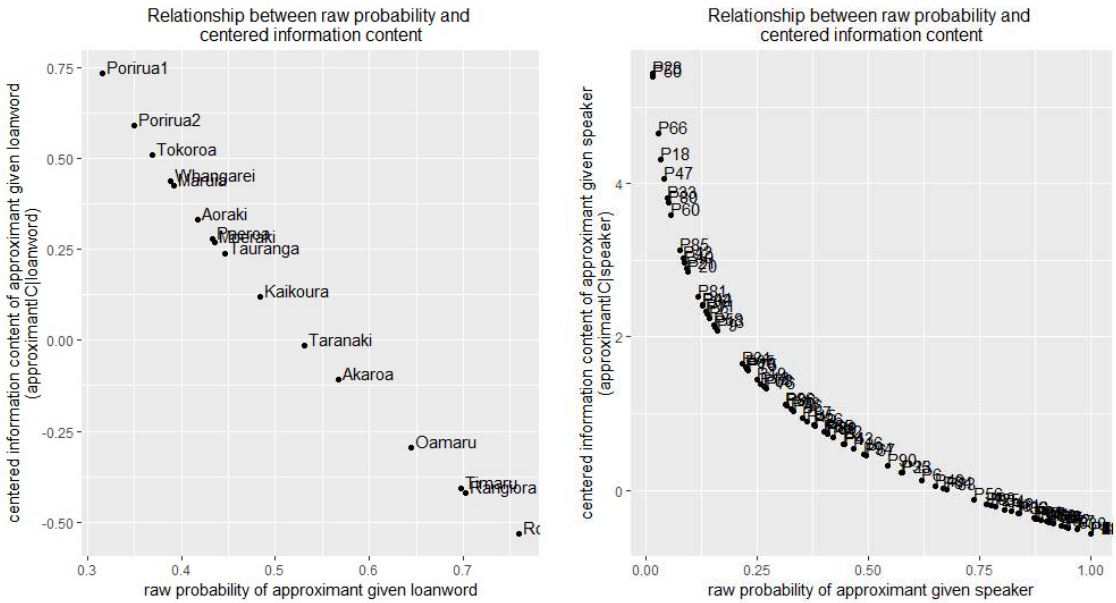

Figure 7.2 Relationship between raw probability and centred information content given loanword (left) and speaker (right) in passage reading task (Experiments 1 and 3)

7.3.3 Measurement of approximant F3

The value of F3 in adapted structure [ɹ] is discussed in this chapter, and thus it is essential to clarify how F3 is measured in the current study. As was discussed in Chapter 3, we made an attempt to annotate the domains including consistent F2 around the lowest F3 in most cases, because F2 is known as an indicator of consonantal domains in many phonetic studies (see Lavoie (2004: 69) and her citations). Although it is still arbitrary to some extent to annotate the domain of inter-vocalic approximants because of their vocalic nature (Umeda 1977 and see discussion in 3.3.4), the annotated region should approximate the domain of [ɹ]. Hence, the measurement of F3 was performed on the basis of this annotated interval. Using a Praat script, the interval of an approximant was divided into three parts: the first 20%, the central 60%, and the final 20%. The first 20% and the final 20% were excluded from the measurement, as they might be likely to be affected by surrounding vowels (Di Paolo et al. 2011). As for the central 60%, it was sub-divided into six parts (domains A-F) by 10%. Figure 7.3 illustrates how an approximant token was divided into these sub-parts. The mean of F3 was measured in each sub-interval using a Praat script, and the lowest F3 value was adopted as the formant value of an approximant token since the lowest value is likely to represent the most extreme part of this consonant. In the case of Figure 7.3, the domain D was chosen as the formant value for this token.

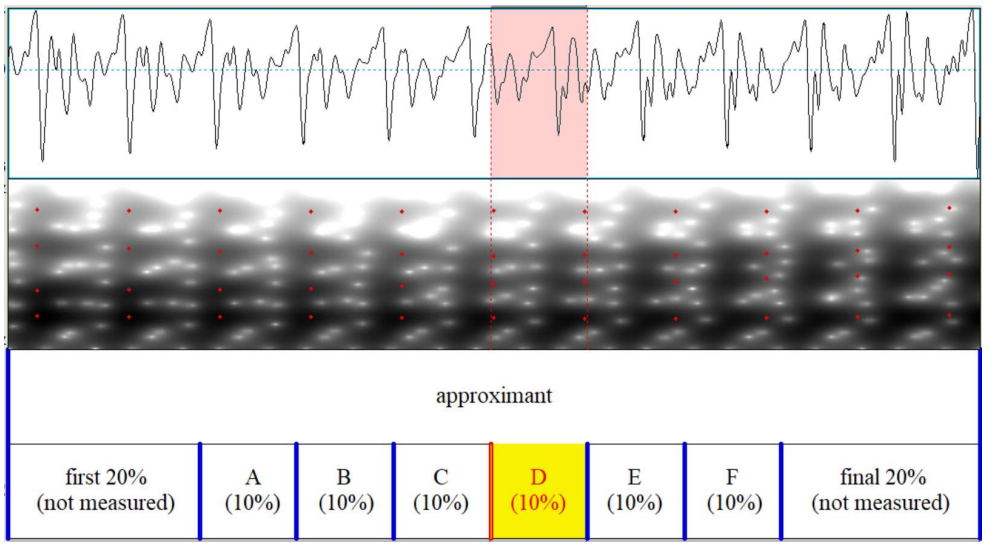

Figure 7.3 Division of approximant to measure lowest value of F3 ("Moeraki" by P2)

These formant values were taken by analysing 5 formants in the region up to 5,500Hz for female speakers and up to 5,000Hz for male speakers (see Boersma & Weenink 2016: FAQ Formant Analysis).

7.4 Results

In this section, we will illustrate the results of the passage-reading task in relation to the F3 value of adapted structure, and show the statistical analyses.

7.4.1 Number of observations

As was discussed in 7.3.1, the current chapter discusses only acoustically identified adapted structure [ɹ] in the passage reading tasks (Experiments 1 and 3). 904 tokens were acoustically identified as approximants in Experiment 1, and 3,570 tokens were acoustically identified as approximants in Experiment 3. In total, 4,474 tokens are statistically analysed in what follows.

7.4.2 Variables

7.4.2.1 Response variable: F3 of adapted structure [ɹ]

Originally, we planned to analyse the raw value of F3 of [ɹ]. However, we could not fit the raw value into a statistical model, because it incurs an error message that requires rescaling. Hence, the raw values were z-scored across the whole data, and the z-scored values are statistically analysed in what follows. Figures 7.4 represent the density of the raw values and the standardized values. As for the raw F3 values, the mean is 1791.45Hz, the median is 1791.97Hz, and the standard deviation is 230.52Hz.

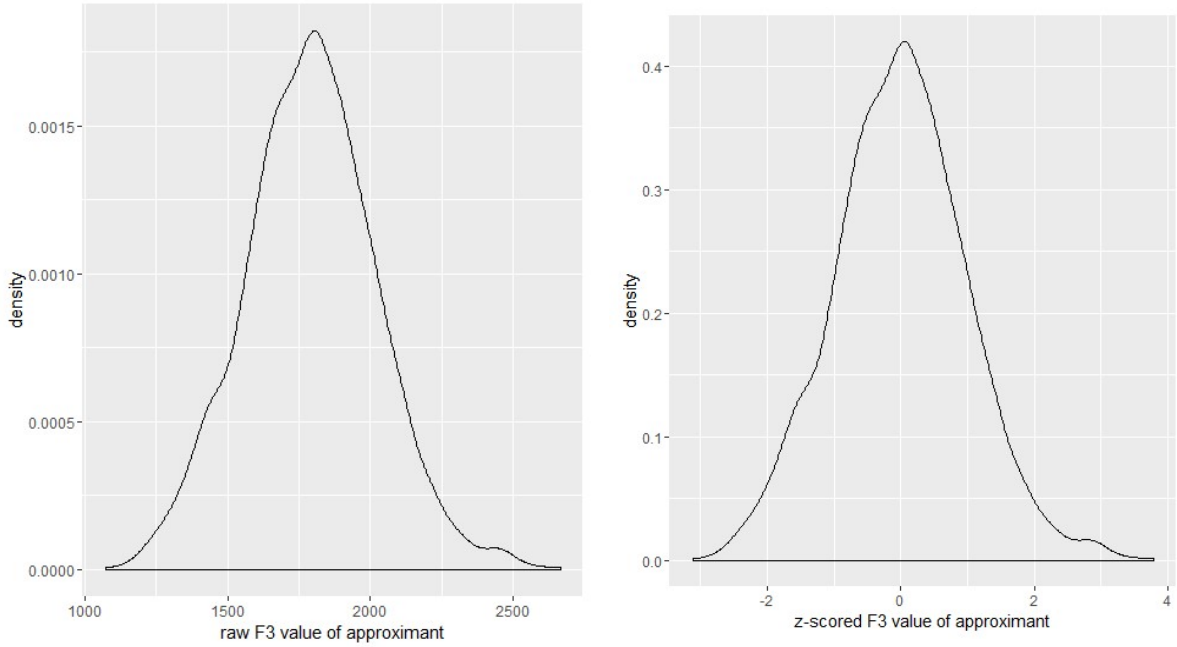

Figure 7.4 Density plot of raw F3 value (left) and z-scored F3 value (right) of adapted structure in passage-reading task (Experiments 1 and 3)

7.4.2.2 Key predictors: IC(ɹ|loanword) and IC(ɹ|speaker)

As was discussed above, the variables of interest are two types of centred information content: IC(ɹ|loanword) and IC(ɹ|speaker). These two variables were calculated from *p*(ɹ|loanword) and *p*(ɹ|speaker), as formulated in (3). These two variables are called *approxIC|loanword* and *approxIC|speaker* respectively in our data frame. The distribution is illustrated in Figure 7.2, and IC(ɹ|speaker) spans a wider range than IC(ɹ|loanword). Recall that there is a negative correlation between the centered information content and the raw probability, that is, the centered information content of imported structure is higher when the raw conditional probability of imported structure is lower, and vice versa.

7.4.2.3 Control variables

We also explore some factors that might affect F3 as control variables, as listed in Table 7.2 below. First, we explore several factors that may affect segmental duration: *precSt*, *folSt*, *SpRate*, *NofSeg*, *subjFreq*, *session*, *precBr*, *folBr*, *passageSpRate*, and *mention*, see 6.4.2.3 and 6.5.2.3. The reason for exploring these factors is that the duration might affect the degree of lowering F3. Speakers could lower F3 of approximants further, when they have longer time to articulate the sounds. In fact, Hay & Maclagan (2012) demonstrate that linking-[ɹ] in high frequency words is produced with higher F3. This could be interpreted to mean that high frequency words are produced with shorter duration, and accordingly approximants are articulated for shorter time, the result of which is that F3 is not lowered well.

Anatomical differences may also affect F3 values. It is known that formant values differ in accordance with speakers due to their anatomical differences (Watt et al. 2011). In order to

control for this effect in the following statistical analyses, we fit *nativeF3* as a control variable. This variable represents a speaker-specific potential F3 value, and was measured by averaging F3 values of inter-vocalic approximants in three native words (*exper̲ience*, *ar̲ea*, and *for̲est*) in old neutral passages within each participant. These three words are all mentioned twice in old neutral passages, and thus the averaged F3 value was calculated on the basis of the six tokens. Note that the measurement of F3 in these native words is the same as that of F3 in the target loanwords as explained in 7.3.3, and the values were z-scored as explained in 7.4.2.1. If the F3 of approximants is affected by the key variable IC(ɹ|speaker) even when controlling for this anatomical difference, it will demonstrate that the F3 value is subject to the speaker-specific social message predictability independently of the anatomical difference.

We also fit *gender* (female vs. male) into our model. It is known that male speakers produce lower formant values in general (Hillenbrand et al. 2009). As discussed in 7.3.3, formant values were taken by analysing 5 formants in the region up to 5,500Hz for female speakers and up to 5,000Hz for male speakers. This different measurement might also cause male F3 values to be lower than female ones. Hence, this variable is expected to show a negative slope, as long as the reference level is female.

Finally, the other variables discussed in Chapter 3 (*topic*, *PC-attitude*, *PC-culture*, *PC-people*, *wordMaoriness*, *speakerPlace*, and *wordPlace*) were also explored, even if they were not expected to affect the duration of a segment.

approxIC|loanword	Information content of adapted structure given loanword (numeric)
approxIC|speaker	Information content of adapted structure given speaker (numeric)
precSt	Vowel preceding /r/ is main-stressed vs. not (binary)
folSt	Vowel following /r/ is main-stressed vs. not (binary)
SpRate	Number of vocalic elements per second within word (numeric)
NofSeg	Number of segments within a target loanword (numeric)
subjFreq	Subjective word frequency (numeric)
session	The first session (before a break) vs. the second session (binary)
precBr	/r/ appears in a loanword preceding a prosodic break vs. not (binary)
folBr	/r/ appears in a loanword following a prosodic break vs. not (binary)
PassageSpRate	Number of syllables per second within passage (numeric)
mention	Mentioned first within a passage vs. second (binary)
nativeF3	Averaged value of F3 in approximants in native words within speaker (numeric)
gender	Produced by female speakers vs. male speakers (binary)
topic	Reading passage is Māori vs. neutral (binary)
PC-attitude	Attitudes towards Māori (numeric)
PC-culture	Relationship with Māori culture (numeric)
PC-people	Relationship with Māori people and speakers (numeric)
wordMaoriness	Subjectively rated words' association with Māori (numeric)
speakerPlace	Participant comes from the North Island vs. the South Island (binary)
wordPlace	Place referred to by a target loanword is in the North Island vs. the South Island (binary)

Table 7.2 List of variables examined in statistical analyses

7.4.3 Linear regression analyses

The 4,474 tokens of acoustically identified [ɹ]-realizations were hand-fitted into a mixed-effects regression model with the *lmer* function in the *lme4* library (Bates et al. 2015) and *lmerTest* library (Kuznetsova et al. 2016) implemented in R (R Core Team 2016). We started with a model with all the variables and two random intercepts for speaker and word without any interactions. Then, 12 variables (*precSt*, *folSt*, *SpRate*, *precBr*, *folBr*, *PassageSpRate*, *mention*, *topic*, *PC-attitude*, *PC-people*, *speakerPlace*, and *wordPlace*) were eliminated one-by-one through pairwise comparisons of models with and without each variable. As for these 12 variables, their interactions with the other variables were not examined, as they are not significant at all. Then, backward elimination was performed manually through pairwise model comparisons using ANOVA tests by taking into consideration all the 2-way interactions of the other 9 variables (*approxIC|speaker*, *approxIC|loanword*, *NofSeg*, *subjFreq*, *session*, *gender*, *nativeF3*, *PC-culture*, and *wordMaoriness*). The elimination was based on t-value, that is, either

a single effect or an interaction with the lowest t-value was eliminated one-by-one. If a model comparison showed no significance (p>.05), then the smaller model was adopted; otherwise, the larger model was adopted. That is, factors that did not reach significance via model comparison were removed. Through this process, *session* was dropped. Finally, by-speaker random slopes for *approxIC|loanword*, *subjFreq*, and *NofSeg* and by-word random slopes for *approxIC|speaker*, *gender*, and *nativeF3* were added to the model, the result of which is that the three factors (*approxIC|loanword*, *wordMaoriness*, and *PC-culture*) were removed from the model. The ANOVA comparison was performed until all remaining predictors show significance, and the following model was selected as the best-fitted model. A Variance Inflation Factor (VIF) test was performed on the final model, and all VIF scores were below 4, which suggest that there is no multicollinearity in the model. The other assumptions of linear models (linearity, homoskedasticity and normality of residuals) were also checked visually by inspecting a residual plot and a histogram of the residuals (see Winter 2013). The best-fitted model is as in Table 7.3 with the reference levels being `gender female`:

zscoredF3~approxIC|speaker+NofSeg+subjFreq+gender+nativeF3

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.22078	0.08076	2.734	0.008477	**
approxIC|speaker	0.14973	0.05670	2.641	0.015968	*
NofSeg	0.32464	0.07062	4.597	0.000251	***
subjFreq	-0.05397	0.02327	-2.320	0.023016	*
gender male	-0.28017	0.12554	-2.232	0.028728	*
nativeF3	0.45995	0.05893	7.805	3.69e-11	***

Table 7.3 Best-fitted model for F3 of approximant

As the dependent variable is the z-scored F3 value of adapted structure, positive coefficients indicate higher F3 values, while negative coefficients represent lower F3 values. As for the variables of interest, only *approxIC|speaker* reaches a significant level (β=0.14, t=2.64, p<0.05). As the slope is positive, this variable suggests that adapted structure is likely to be produced with higher F3, when the information content given a speaker is higher, that is, when the selection of adapted structure as opposed to imported structure is less predictable given a speaker. Figure 7.5 illustrates this relation between F3 and *approxIC|speaker*. The vertical axis shows the z-scored F3 value and the horizontal axis shows the information content of imported structure given a speaker. The blue line represents a regression line, and the dots represent individual datapoints Note that the horizontal axis corresponds with the vertical axis of the right-hand figure of Figure 7.2.

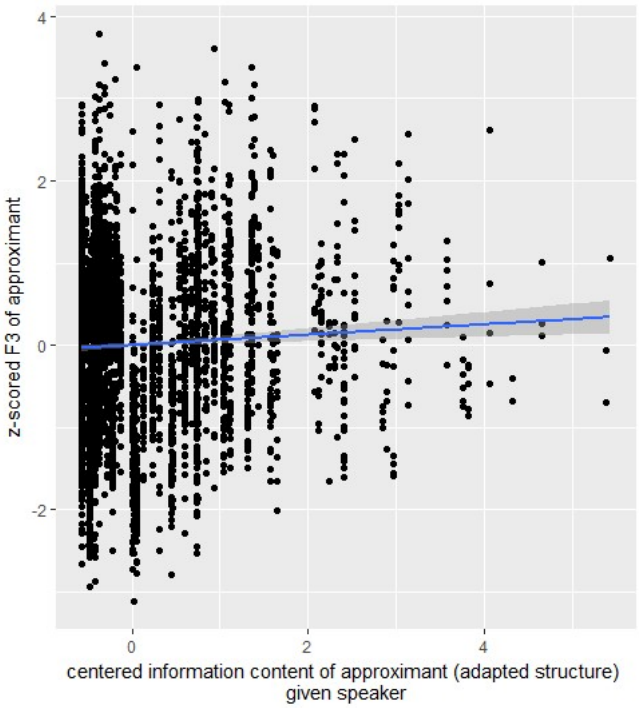

Figure 7.5 Scatter plot of relationship between IC(ɹ|speaker) and F3 of approximant

On the other hand, *approxIC|loanword* does not reach a significant level (p=0.25). However, we would like to mention that this variable reaches a significant level when no random slopes are fitted for this variable (p<0.05), and the direction is in line with IC(ɹ|speaker). Figure 7.6 represents the relationship between F3 and *approxIC|loanword*. Once again, the slope is positive, that is, adapted structure with higher information content (i.e., lower predictability) given a loanword is likely to be produced with higher F3. Note that the horizontal axis corresponds with the vertical axis of the left-hand figure of Figure 7.2.

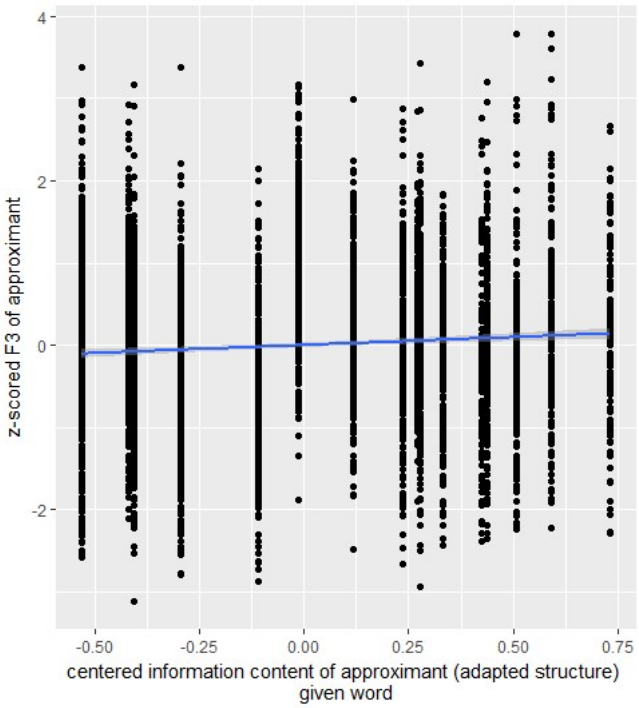

Figure 7.6 Scatter plot of relationship between IC(ɹ|loanword) and F3 of approximant

As for the control variables, three variables (*NofSeg*, *subjFreq*, *gender*, and *nativeF3*) showed statistically significant effects: adapted structure is produced with higher F3 in longer words (β=0.32, t=4.59, p<0.001); adapted structure is produced with lower F3 in higher frequency words (β=−0.05, t=−2.32, p<0.05); adapted structure is produced with lower F3 by male speakers (β=−0.28, t=−2.23, p<0.05); adapted structure is produced with higher F3 by speakers producing higher F3 in native words (β=0.45, t=7.8, p<0.001). Note that *gender* and *nativeF3* correlate fairly strongly (r=0.67), but their VIF values are 1.88 and 1.85. This suggests that our model does not have a problem of multicollinearity. The other variables did not reach a significant level, and therefore they were removed from the best-fitted model. The variables showing significant effects are summarized in Table 7.4.

approxIC|speaker	Adapted structure is likely to be produced with higher F3, when the information content given a speaker is higher (p<0.05).
NofSeg	Adapted structure is produced with higher F3 in longer words (p<0.001).
subjFreq	Adapted structure is produced with lower F3 in higher frequency words (p<0.05).
gender	Adapted structure is produced with lower F3 by male speakers (p<0.05).
nativeF3	Adapted structure is produced with higher F3 by speakers producing higher F3 in native words (p<0.001).

Table 7.4 Summary of finding on F3 of adapted structure

7.5 Discussion

The aim of this section is to discuss the statistical results in relation to our theoretical framework. As with imported structure, it was found that redundancy in adapted structure (i.e., degree of F3-lowering) is affected by several factors. First, it was found that approximants are produced with, less redundancy, that is, higher F3 in longer loanwords. This might be because a segment is likely to be produced with shorter duration in longer words (Lindblom 1968), and thus the F3 could not be lowered well.

The effects of *gender* and *nativeF3* are as expected in 7.4.2.3. It is known that male speakers produce lower F3 in general, and this is found to be true in the production of loanwords. The significance of *nativeF3* suggests that speakers producing approximants with lower F3 in native words produce those with lower F3 in loanwords as well. These effects could be due to anatomical differences between speakers. It is worth commenting on the observation that *gender* shows a significant effect even while controlling for anatomical differences with *nativeF3*. Note that these two variables correlate fairly strongly (r=0.67), but since their VIF values are lower than 4.0, the model in Table 7.3 does not have a problem of multicollinearity, as noted in 7.4.3. That is, the effects of *nativeF3* and *gender* on F3 values of adapted structure are not exactly the same. There are two possible interpretations of this. First, *nativeF3* may not capture the anatomical differences perfectly, while *gender* captures extra-anatomical differences. We calculated *nativeF3* based on only six tokens from each speaker, which may not be sufficient to accurately reflect potential differences. The other interpretation is that male speakers might store a larger number of exemplars with adapted structure, and a target exemplar in production is more likely to be averaged with other exemplars with lower F3 values (i.e., adapted structure), the result of which is that male speakers produce adapted structure with extra-lower F3 values. This averaging-based account will be more fully explained in 7.5.3. As *gender* is not well-balanced in our experiments, we did not explore the effect of *gender* on the likelihood of adaptation vs. importation in the statistical analyses in Chapters 3-5 (see 2.2.1), but our data suggests that male speakers are slightly more likely to produce adapted structure than female speakers. For example, the rate of adaptation in Experiment 3 is 53.4% for male speakers, whereas it is 49.2% for female speakers. This observation might support the averaging-based account discussed below.

Finally, it was found that approximants are produced with lower F3 in higher frequency loanwords. Recall that we employ subjective word frequency rather than objective one. This result is opposite from the result reported by Hay & Maclagan (2012) about linking /r/ in native words. There may be two possible accounts. One account is that higher frequency loanwords are incorporated into the English lexicon more fully than lower frequency loanwords, and they are more likely to be pronounced in the same way as native words. As approximants in English native words are produced with lower F3 values, those in higher frequency loanwords might also be produced with lower F3 values. The other account may relate to the mechanism of averaging exemplars, as will be discussed in more detail in 7.5.3. Higher frequency loanwords

are known to undergo adaptation more often than lower frequency loanwords (Haugen 1950), although word frequency is not a statistically significant predictor of adaptation rate in the current study (see Chapters 3-5). This implies that exemplars representing higher frequency loanwords could be stored with adapted structure more often. Hence, a target exemplar is more likely to be averaged with exemplars with lower F3 values (i.e., adapted structure) in the production of higher frequency words, the result of which is that approximants in high frequency loanwords are produced with lower F3.

On the other hand, the other control variables do not reach a statistically significant level, and they were removed from the best-fitted model. In the last chapter, it was demonstrated that *folSt*, *folBr*, and *SpRate* affect the redundancy (i.e., duration) in imported structure. These variables did not show significant effects on redundancy (i.e., F3) in adapted structure. This might suggest that duration and formant structure are affected by prosodic factors in a different manner. Further exploration of the differences is left for future study.

In what follows, we will discuss the two key variables, IC(ɹ|loanword) and IC(ɹ|speaker), in order to inform our understanding of how adapted structure is processed in the production of loanwords. After the discussion of Prediction 7 in 7.5.1 and 7.5.2, we will discuss an alternative account based on exemplar-averaging in 7.5.3.

7.5.1 Predictability given speaker

First, let us discuss the effect of IC(ɹ|speaker) on F3 values of approximants [ɹ]. The effect of this variable is statistically significant in our dataset collected from the passage-reading task (β=0.14, t=2.64, p<0.05). However, the direction of this predictability effect is opposite from what was predicted on the basis of hypotheses about articulatory biases (3a, 3b, 3c, 3d) in 7.2. Our data shows that adapted structure with *higher predictability* given a speaker is more likely to be pronounced with *lower* F3, see Figure 7.5.

This effect on adapted structure might be viewed as contrary to our hypotheses about message-oriented articulatory biases, even though the hypotheses about message-oriented articulatory biases (3a-d) were shown to be well-supported by the predictability effects on redundancy in imported structure (see 6.6). Rather, we interpret this result to suggest that the averaging mechanism has a strong effect on a F3 value of adapted structure, which may conceal the effect of the message-based articulatory biases on the F3 value. This alternative account based on exemplar-averaging is discussed further in 7.5.3.

7.5.2 Predictability given loanword

Contrary to IC(ɹ|speaker), the effect of IC(ɹ|loanword) is not found to be statistically significant (p=0.25), although it is significant when no random slopes are fitted for this variable in the statistical analysis and the direction is in line with that of IC(ɹ|speaker), see Figure 7.6. That is, the data reported in this chapter do not support our prediction: adapted structure with higher predictability given a loanword is more likely to be pronounced with *higher* F3

[Prediction 7].

This null result could be explained in the same way as in the last chapter. Recall that the predictability given a loanword does not show significant effects on redundancy in imported structure in the passage-reading task either, see Section 6.5 and Table 6.7. We speculate that these null results might be due to the small set of loanwords employed in the passage-reading task. The passage-reading task employs only 14 place names borrowed from te reo Māori, and the narrow set might not enable us to explore a variety of values of the predictability given a loanword. Further exploration of this word-given predictability using a larger data is left for future study.

7.5.3 Another theoretical interpretation: averaging exemplars

Before concluding this chapter, we would like to offer an alternative theoretical interpretation of the results reported above. Recall that we assume that (2c) the production target is determined by averaging phonetic values of a target exemplar and surrounding exemplars. This assumption is widely accepted in previous literature (Pierrehumbert 2001; 2002; Wedel 2006; Hay & Maclagan 2012) to account for entrenchment, with the detail in 1.7.3. This section demonstrates that the averaging-based account can deduce an opposite prediction from the message-oriented account, for F3 of adapted structure. That is, the averaging-based account could capture the results reported in the current chapter.

First, we would like to consider the effect of IC(ɹ|speaker) on F3 values of adapted structure. With respect to formant values, we could posit that an exemplar with [ɹ] is stored with a lower F3 value and an exemplar with [ɾ] is stored with a null F3 value, because approximants are known to have lower F3 in comparison to the other sounds (see 7.2.1), whereas tap sounds consist of closure and release phases without inherent formant structure. As long as formant structure could be averaged through the process of blending exemplars (2c), the averaging-based account would predict that adapted structure with *higher predictability* is produced with *lower F3*. The reason is that a target exemplar is more likely to be averaged with surrounding exemplars with lower F3 values (i.e., adapted structure) when adapted structure is more predictable given a speaker, that is, when a larger number of exemplars with adapted structure are stored within the cognitive system. Similarly, the averaging-based account would predict that adapted structure with *lower predictability* is produced with *higher F3*. This is because a target exemplar is more likely to be averaged with surrounding exemplars with null F3 values (i.e., imported structure), when adapted structure is less predictable given a speaker, that is, when a larger number of exemplars with imported structure are stored within the cognitive system. This prediction is illustrated in Figures 7.7 and 7.8. Figure 7.7 shows that exemplars with adapted structure are more likely to be averaged with adapted structure, when a higher number of exemplars with adapted structure are stored, and vice versa. Imagine that *SpeakerX* represents 750 exemplars with imported structure and 250 exemplars with adapted structure, with the reverse being assumed for *SpeakerY*. The bold-circled letter represents a target

exemplar that belongs to the activated category, and the other circled letters represent surrounding exemplars that are selected additionally. As is clear, a target exemplar with adapted structure is more likely to be averaged with surrounding exemplars with adapted structure, when the higher number of exemplars with adapted structure are represented in a cognitive system, and vice versa.

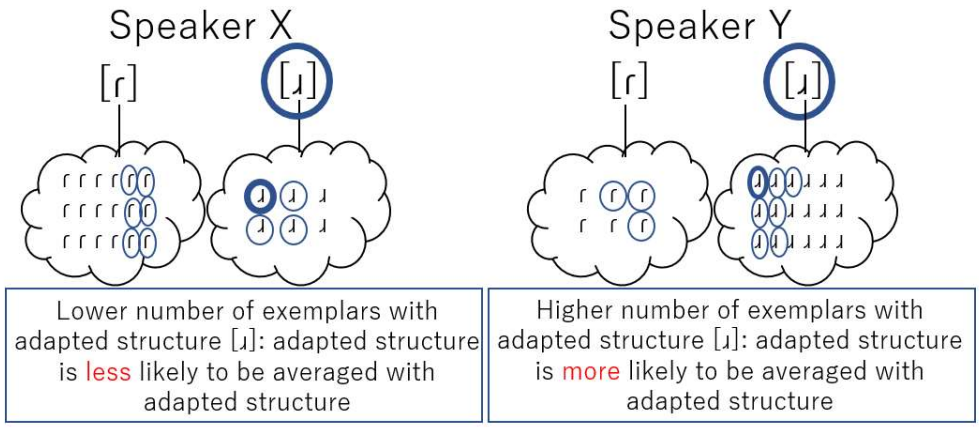

Figure 7.7 Averaging of exemplars with adapted structure and imported structure

Figure 7.8 illustrates what the outcome of averaging exemplars with adapted structure and imported structure would be like. This figure is based on Figure 1.13. The red line indicates F3 transitions, and the box represents the range of phonetic variability in adapted structure [ɹ]. When an exemplar with adapted structure is averaged with more exemplars with adapted structure, it is produced with typical formant structure, that is, a lower F3 value (further to the right in the figure); when it is averaged with more exemplars with imported structure, it is produced with atypical formant structure, that is, a non-lowered F3 value (further to the left inside the box in the figure).

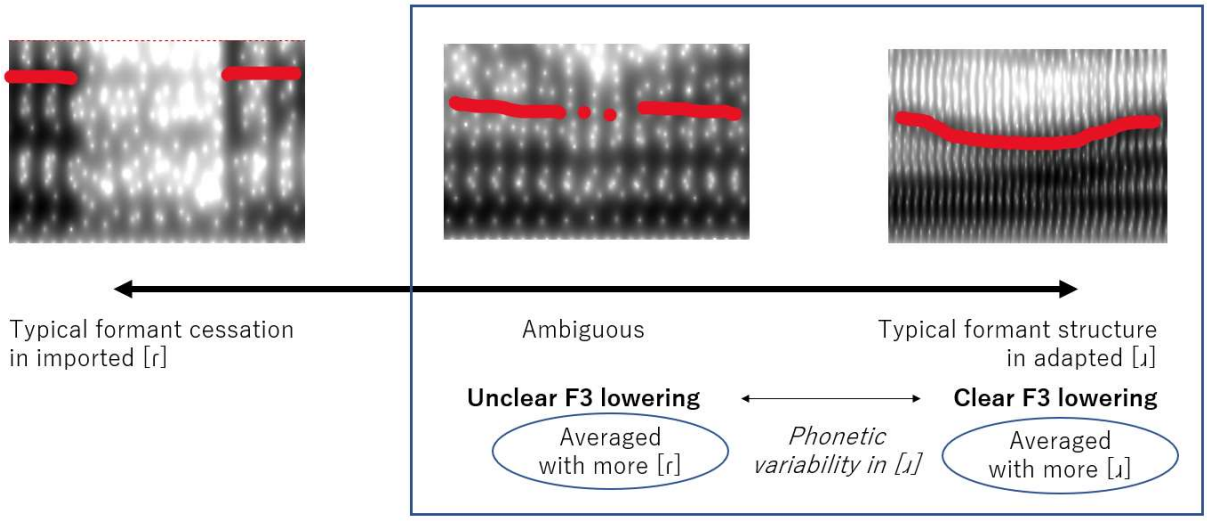

Figure 7.8 Phonetic variability in adapted structure

This prediction is simulated in Figure 7.9. For simplicity, we assume that [ɾ] is stored with a relative formant value 0, [ɹ] is stored with a relative formant value around negative 50 points, and ten exemplars are chosen in a random way and averaged to determine the production target. If we average ten exemplars within each cognitive system (i.e., speaker) in a random manner 1,000 times, then the outcome would be as in Figure 7.9. It is successfully demonstrated that the formant value of adapted structure with lower information content (i.e., higher predictability) given a speaker is expected to be produced with a relatively lower F3 value. The code to generate this figure is provided as Appendix G.

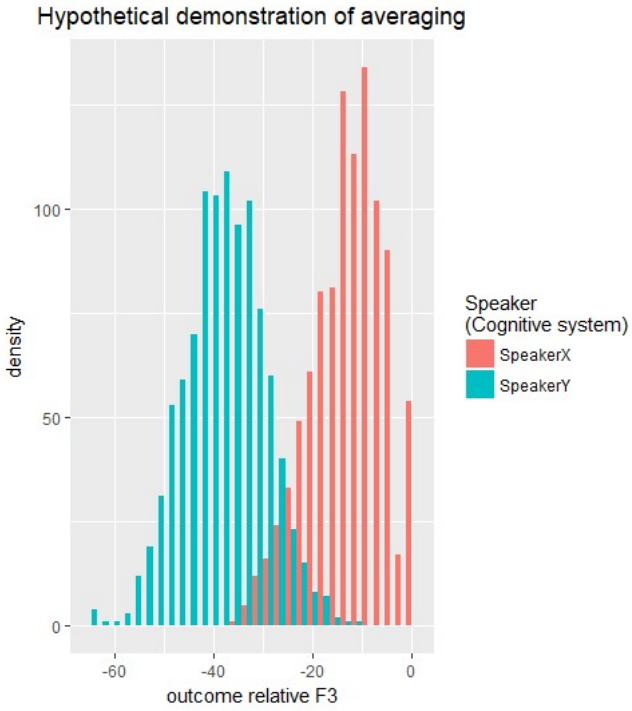

Figure 7.9 Averaging-based account for relationship between predictability and F3 of adapted structure

In this way, the averaging-based prediction is in line with the result reported above. We could neatly capture the effect of IC(ɹ|speaker) on a F3 value of adapted structure, by positing that formant values of chosen exemplars can be averaged in determining a production target.

Finally, we would like to interpret the effect of IC(ɹ|loanword) from the averaging-based view. As with IC(ɹ|speaker), it can be deduced from this account that adapted structure with *higher predictability* given a word is more likely to be pronounced with *lower F3*. Once again, the averaging-based account and the message-oriented account generate conflicting predictions. Our results show that IC(ɹ|loanword) is not statistically significant (p=0.25), but we would like to note that the direction of the effect of the word-specific predictability is in line with this averaging-based account (see Figure 7.6). The null result might be due to the narrow set of loanwords employed in the passage-reading task, as discussed in 7.5.2. The future exploration of this predictability effect using a larger dataset might strengthen this averaging-based

interpretation.

In this way, our results may support the assumption about exemplar-averaging (2c), because the results are in line with the exemplar-averaging based account. Recall that the result is opposite from the prediction by the message-oriented account [Prediction 7], as discussed in 7.5.1. However, we believe that this result does not completely negate the hypotheses about message-oriented articulatory biases (3a-d). Rather, we speculate that the exemplar-averaging process has a very strong effect on the production of adapted structure, and therefore the effect of the message-oriented articulatory biases is concealed. The reason why the message-oriented biases should not be discarded is that they need to be posited to account for the redundancy in imported structure (see 6.6.4). The averaging-based account could not capture our results in relation to imported structure. As with adapted structure, the averaging-based account would deduce the opposite prediction about imported structure from the message-oriented account, that is, it predicts that imported structure with *lower predictability* is produced with *shorter duration* (i.e., formant cessation), and vice versa. This is because formant cessation in imported structure should be ambiguous, that is, shorter, when it is more likely to be averaged with adapted structure. As with Figure 7.7, exemplars with imported structure should be averaged with those with adapted structure more often, when they are less predictable, that is, the number of exemplars with imported structure is smaller in exemplar space. This averaging-based prediction is not in line with what was reported in the previous chapter. This will be discussed in more depth in 8.3.

In sum, the redundancy in adapted structure is in line with the averaging-based account, while that in imported structure is in line with the message-oriented account. This discrepancy raises a big question about the difference of the two structures. Namely, why would adapted structure be strongly affected by the exemplar-averaging process, but why imported structure be strongly influenced by the message-oriented articulatory biases? This might be because the social message carried by imported structure is salient in the NZ society, while the message carried by adapted structure is non-salient or neutral. The imported structure [ɾ] is not native structure, so may carry a strong social message. It may explicitly express the solidarity with Māori. On the other hand, adapted structure [ɹ] is native structure and widely used in the English lexicon, and thus the social meaning is likely neutral. Speakers may not explicitly express a social message dissociated from Māori by choosing adapted structure as opposed to imported structure. This is why imported structure is likely to be affected by the social-message-oriented articulatory biases, but adapted structure is not. It is plausible that the social-message-oriented biases strongly affect a production target for a variant with salient social messages, but they weakly affect a production target for that with non-salient social messages. Note that we do not claim that imported structure is affected only by articulatory biases and adapted structure is affected only by exemplar-averaging processes. Rather, we assume that the two structures are affected by both mechanisms, and the degree of influence of each mechanism differs between the two structures depending on the saliency of the social message. The message-oriented

account and the averaging-based account will be discussed in tandem in the concluding chapter.

7.6 Summary

Now, let us summarize this chapter. We explored the phonetic implementation of adapted structure in this chapter. In particular, we explored how F3 of adapted structure is influenced by the predictability of choosing adapted structure as opposed to imported structure. We explored two types of predictability, *p*(ɹ|speaker) and *p*(ɹ|loanword), which were transformed into centred information content in statistical analyses. It was found that the effect of *p*(ɹ|speaker) is statistically significant, but the direction is opposite from our message-oriented prediction [Prediction 7]. That is, adapted structure with *higher predictability* given a speaker is likely to be produced with a *lower F3* value. In order to account for this opposite result, we pointed out the alternative account based on averaging exemplars (see 7.5.3). We speculated that the exemplar-averaging process has a strong effect on the production of adapted structure, and consequently the effect of message-based articulatory biases may be concealed. The reason is that speakers may not explicitly express a social message dissociated from Māori by producing adapted structure, and therefore the message-oriented biases do not strongly affect a production target for adapted structure. On the other hand, the effect of *p*(ɹ|loanword) is not found to be significant. This might be due to the narrow set of loanwords employed in the passage-reading task, as pointed out in the last chapter.

In this way, the current chapter tests the hypotheses about (0) predictability representation and (3) message-oriented articulatory biases in our theoretical framework, and informs our understanding on how imported structure is processed in accordance with the social message predictability. As is discussed above, the results do not well support the hypotheses about articulatory biases. However, the results could be captured by positing that (2c) formant values of several exemplars are averaged and a production target is determined. In the next chapter, we will discuss the findings about the formant values of adapted structure (the current chapter) and the findings about the duration of imported structure (Ch.6) alongside each other, with the detail in 8.2.2 and 8.3. This discussion informs our understanding of how the exemplar-averaging process and the message-oriented articulatory biases govern the redundancy in the production of loanwords.

Ch.8 Conclusion

The aim of this thesis is to address the theoretical question **[RQ1]** *how imported structure and adapted structure are stored in the mind of a borrower and processed in the production of a loanword*. Chapter 1 has posited a theoretical framework to address this question. In order to assess the theoretical framework, we have investigated two concrete questions: **[RQ1a]** *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors*, and **[RQ1b]** *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message*.

In Chapters 3-5, we addressed the first concrete research question about the likelihood of adaptation vs. importation [RQ1a], which yields four specific research questions [RQ2-5]. Addressing the four questions develops our understanding of the relationship between loanword phonology and sociolinguistic factors. We demonstrated that some sociolinguistic factors affect the likelihood of adapted structure [ɪ] vs. imported structure [ɾ] in NZE loanword phonology. These results can be encapsulated by our theoretical framework: they can accurately be predicted by positing that exemplars with imported structure are stored closely in relation to the social concept "Māori," and that the strength of imported structure is updated and determined in daily usage. The results also suggest that variation in loanword phonology is socially meaningful, because it is a type of inter- and intra-speaker variation. On the basis of this variation, we argued that imported structure carries a social message associated with Māori and adapted structure carries a social message dissociated from Māori.

On the basis of the argument for the social messages, Chapters 6 and 7 have addressed the second concrete research question about redundancy in adapted structure and imported structure [RQ1b], which leads to two specific research questions [RQ6-7]. Addressing the two research questions increases our understanding of the relationship between the realization of a linguistic unit and the predictability. It was demonstrated that the realizations of imported structure and adapted structure are both affected by the predictability of choosing one variant against the other variant. However, the direction is different between the two variants: when it is more predictable from context, imported structure is produced with *less* acoustic redundancy (i.e., shorter formant cessation), while adapted structure is produced with *more* acoustic redundancy (i.e., a lower F3 value). We speculate that the redundancy in the two structures is likely to be affected by different parts of our theoretical framework, i.e., imported structure is affected strongly by social-message-oriented biases, while adapted structure is affected strongly by exemplar-averaging processes. This speculation is plausible in that imported structure may carry a salient social message while adapted structure may not, and it is discussed in more detail in 8.3.

This chapter summarizes the findings explored throughout this thesis. Section 8.1 summarizes the findings of the six specific research questions [RQ2-7]. On the basis of these

findings, Section 8.2 summarizes the discussions about the abstract research question [RQ1]. In particular, we will demonstrate how our theoretical framework, which was presented in Chapter 1, can account for the results of [RQ1a] the likelihood of adaptation vs. importation and [RQ1b] the redundancy in adapted structure and imported structure. Section 8.3 discusses further implication about message-oriented biases vs. exemplar-averaging, and Section 8.4 points out the limits of the current thesis and future directions. Section 8.5 offers a conclusion of this thesis.

8.1 Concrete research questions: realization of loanwords in production

8.1.1 Sociolinguistic effects on likelihood of adaptation vs. importation

The goal of this section is to summarize the findings about [RQ1a] *the extent to which the selection of a variant in loanword phonology is influenced by sociolinguistic factors*. This concrete question yields the four specific research questions [RQ2-5]. RQ2 and RQ3 are regarding situation-specific sociolinguistic effects on the likelihood of adaptation vs. importation, and RQ4 and RQ5 are about speaker-specific and word-specific effects respectively:

RQ2: "Is the likelihood of adaptation vs. importation affected by topic in speech?"
RQ3: "Is the likelihood of adaptation vs. importation affected by cultural images?"
RQ4: "Is the likelihood of adaptation vs. importation affected by speakers' association with a source language and its culture?"
RQ5: "Is the likelihood of adaptation vs. importation affected by words' association with a source language and its culture?"

These questions were addressed by using the two passage-reading tasks (Experiments 1 and 3) and the word-list reading task (Experiment 2). The findings in relation to the predictions are summarized in Table 8.1. Recall that participants 1-32 took part in both Experiments 1 and 2, and participants 33-96 took only Experiment 3. Since Experiment 1 is not designed to manipulate the variable of *cultural image* and Experiment 2 is not designed to manipulate the variable of *topic*, these two cells are removed from the table. *SG* indicates that a variable is statistically significant ($p<0.05$) in an experiment on the top, *TR* indicates that the variable shows a trend (i.e., $p<0.1$), and *n.s.* indicates that the variable is not statistically significant. *in pred* indicates that the direction is as predicted, while *in opp* indicates that the direction is not predicted.

Prediction		*Participant 1-32*		*Participant 33-96*
		Experiment 1	*Experiment 2*	*Experiment 3*
Pred 2	*topic*	SG in pred		SG in pred
Pred 3	*cultural image*		TR in pred	SG in pred & opp
Pred 4	*PC-attitude*	SG in pred	SG in pred	TR in pred
	PC-culture	TR in pred	n.s.	SG in pred
	PC-people	n.s.	n.s.	n.s.
Pred 5	*Words' assoc. with Māori*	n.s.	SG in pred	n.s.

Table 8.1 Summary of finding about RQ 2-5 (SG: statistically significant (p<0.05); TR: showing a trend (p-value around 0.1); n.s.: not significant; in pred: in predicted direction; in opp: in direction opposite from predicted)

In what follows, we will discuss these findings one by one.

First, let us discuss the effect of *topic* [RQ2]. This factor is explored using the two passage-reading tasks (Experiments 1 and 3), in which the participants read passages about Māori and those about New Zealand life. It was found that this effect is statistically significant in both of the experiments where *topic* was a predictor (Experiments 1 and 3), and that the direction of the effect is as predicted: [Prediction 2] imported structure is more likely to be produced when a participant speaks about Māori. As this effect is supported by the results of the two experiments, we can conclude that the topic effect is robust on the likelihood of adaptation vs. importation.

Second, we address the effect of *cultural image* [RQ3]. This effect is explored in Experiments 2 and 3, in which participants read aloud carrier sentences or passages with a set of Māori loanwords while seeing Māori-like cultural frames or neutral frames. This variable shows a trend (p=0.09) in the predicted manner in Experiment 2: [Prediction 3] imported structure is more likely to be produced when a Māori cultural image is presented. We speculated that this nuanced result might be due to the rapid shifting of cultural images in Experiment 2 (see 4.5.1). In order to resolve the methodological issue, we designed Experiment 3 using a passage-reading task manipulating cultural images, but the result is nuanced again. It was found that the cultural image effect is as predicted for the participants beginning with neutral frames, but the effect is in the opposite direction for those beginning with Māori frames. We pointed out that the significant interaction between *frame* and *firstFrame* might be confounded with an order effect (see 5.5.2). In sum, we did not find that cultural images altered the likelihood of choosing adapted structure vs. imported structure.

Next, we consider the effects of a given speakers' association with Māori [RQ4]. This factor is measured using participants' responses to questionnaires (see Chapter 2), which were reduced into three principal components: *PC-attitude* (attitude towards Māori culture and

language), *PC-culture* (relationship with Māori culture and language, and individual proficiency in Māori), and *PC-people* (relationship with Māori people, and neighbourhood proficiency in Māori). We offered a prediction that speakers strongly associated with Māori are more likely to produce imported structure [Predictions 4a and 4b]. This prediction is partially supported in the current study. First, *PC-people* shows no significant effect on the likelihood of adaptation vs. importation throughout this thesis. The reason might be because almost all participants in the current study have a very weak relationship with Māori people and Māori speakers (see 2.2.2.3), therefore might not be suitable to test this variable. That is, our dataset does not provide evidence that imported structure is more likely to be produced by borrowers strongly related with Māori people or speakers, but it would be worth exploring speech by NZE speakers strongly related with Māori people and speakers in future work. Second, *PC-culture* was found to be statistically significant in Experiment 3 and shows a trend in Experiment 1 in the predicted manner. This factor did not reach significant levels in Experiment 2, and we speculated that possible effects might be concealed by the ceiling effect, as the rate of importation is higher in the word-list reading task in comparison to the other passage-reading tasks (see 4.5.2). That is, our results demonstrate the tendency that borrowers strongly related with Māori culture and language produce imported structure at a higher rate. Finally, the effect of *PC-attitude* is statistically significant in Experiments 1 and 2, and it shows a trend in Experiment 3. The direction is always as predicted. This suggests that borrowers with positive attitudes towards Māori culture and language are more likely to produce imported structure. In this way, the current study found that imported structure is more likely to be produced by speakers with more positive attitudes towards the source language and culture (*PC-attitude*) and those with stronger relationship with the source language and its culture (*PC-culture*).

Finally, let us discuss the effect of words' association with Māori [RQ5]. We deduced [Prediction 5] that loanwords strongly associated with Māori are more likely to be produced with imported structure. In order to test this prediction, the participants were asked to answer how strongly a target loanword is associated with Māori, and the rated values were z-scored by each speaker (see 2.3). These z-scored values were then explored as a predictor of the likelihood of adaptation vs. importation. Recall that this factor is called *wordMaoriness* in the statistical analyses. It was found that this factor is not statistically significant in Experiments 1 and 3 (passage-reading tasks), although the direction is trending as predicted. On the other hand, this effect is statistically significant in the predicted manner in Experiment 2 (word-list reading task). The reason why this effect is statistically significant only in Experiment 2 might be because the set of target loanwords in Experiment 2 is larger in comparison with those employed in Experiments 1 and 3 (see 4.5.3). The larger set of target loanwords in Experient 2 may enable us to explore a wider range of words' association with Māori. This could be interpreted to mean that the likelihood of adaptation vs. importation is affected by word-specific associations with the source language.

The above results suggest that the variation in loanword phonology depends on some

sociolinguistic factors. These findings increase our understanding of the relationship between loanword phonology and sociolinguistic variables, which has been less studied in previous literature. They suggest that, rather than regarding loanword adaptation as being governed by strictly phonological (LaCharité & Pradis 2005) or phonetic properties (Peperkamp & Dupoux 2002), the study of loanword phonology needs to be embedded in more general theories of linguistic variation, particularly those that strive to account for the behaviour of sociolinguistic variables. As stated throughout this thesis, our theoretical framework is based on Exemplar Theory (Pierrehumbert 2001; 2002), which allows us to account for these sociolinguistic effects (see 8.2.1). In addition, our results suggest that the variation in loanword phonology is socially meaningful, because it is a type of both an inter-speaker variation and an intra-speaker variation (see 3.5.4). Although the detailed social messages carried by adapted structure and imported structure need to be explored further in future work, we can hypothesize that adapted structure and imported structure carry different social messages. It could be posited that each structure carries the following social messages, on the basis of the observation that adapted structure is more likely to be used by speakers weakly associated with Māori and imported structure is more likely to be used by speakers strongly associated with Māori:

(5) Social messages carried by adapted structure and imported structure in loanwords

Variation	Variant	Carried messages
/ɪ/	[ɹ]	Social message dissociated from Māori[14]
	[ɾ]	Social message associated with Māori

8.1.2 Predictability effects on redundancy in pronunciation of loanword

Next, let us summarize the findings about [RQ1b] *to what extent the production of a variant in loanword phonology is affected by the predictability of the social message*. On the basis of the argument that imported structure and adapted structure carry different social messages, we addressed this concrete research question, which leads to two specific research questions [RQ6-7]. RQ6 is about redundancy in imported structure (i.e., duration of [ɾ]), and RQ7 is related to redundancy in adapted structure (i.e., degree of lowering F3 of [ɹ]):

RQ6: "Is the duration of imported structure affected by the predictability of the social message (i.e., the selection predictability of imported structure)?"

RQ7: "Is the F3 of adapted structure affected by the predictability of the social message (i.e., the selection predictability of adapted structure)?"

[14] As discussed in 8.3, the social message expressed by choosing adapted structure may be neutral or non-salient.

These questions were addressed by exploring the data analysed in Chapters 3-5 to study the likelihood of adaptation vs. importation, that is, those collected from Experiments 1-3. The findings are summarized in Table 8.2. Recall that the data collected from the two passage-reading tasks (Experiments 1 and 3) were analysed alongside each other, as the larger set of data represents reality better. The word-list reading task was statistically analysed separately due to the different experimental nature. As noted in 7.3.1, the data from the word-list reading task are not analysed to address RQ7 due to the small number of /r/-realizations as adapted structure [ɹ]. Hence, the two cells are removed from the table. The notations are the same as those employed in Table 8.1.

		Participant 1-96	*Participant 1-32*
		Passage-reading (Exp 1 and 3)	*Word-list reading (Exp 2)*
Pred 6	*p(ɾ|loanword)*	TR in pred	SG in pred
	p(ɾ|speaker)	n.s.	n.s.
Pred 7	*p(ɹ|loanword)*	n.s.	
	p(ɹ|speaker)	SG in opp	

Table 8.2 Summary of finding about RQ 6 and 7

First, we would like to mention about the redundancy in imported structure [RQ6]. We explored two types of predictability: predictability of imported structure [ɾ] given a loanword *p(ɾ|loanword)* and that given a speaker *p(ɾ|speaker)*. Our prediction [Prediction 6] is that imported structure is produced with shorter duration when the social message is more predictable given a loanword and given a speaker, that is, when it is more predictable that imported structure is chosen as opposed to adapted structure, all else being equal. It was found that the redundancy in imported structure is affected by the predictability of the social message given a loanword in the predicted manner. That is, imported structure is produced with shorter duration when the selection of imported structure as opposed to adapted structure is more predictable given a loanword, and vice versa. This effect is statistically significant ($p<0.01$) in the passage-reading task, and it shows a trend ($p=0.09$) in the word-list reading task. It was speculated in 6.6.1 that the larger set of loanwords employed in the passage-reading task enables us to explore a variety of values of the predictability given a loanword, and consequently this variable showed a statistically significant effect in the word-list reading task. On the other hand, our statistical analysis does not indicate that the redundancy is affected by the predictability of the social message given a speaker. This predictability was not found to be statistically significant in either the passage-reading task ($p=0.76$) or the word-list reading task ($p=0.44$). As discussed in 6.6.2 and restated in 8.2.2, this implies that the hypothesis (0e) about the predictability given a speaker would be tentative and should be discarded or modified.

Next, let us discuss the redundancy in adapted structure [RQ7]. As with imported structure,

we predicted that less redundancy is added in adapted structure [ɹ] with higher predictability. Since we hypothesized that redundancy in adapted structure negatively correlates with the F3 value, we deduced [Prediction 7] that adapted structure is produced with a *higher* F3 value when the social message is *more predictable* given a loanword and given a speaker, that is, when it is *more predictable* that adapted structure is chosen as opposed to imported structure, all else being equal. First, it was found that there is no significant effect of the predictability given a loanword *p(ɹ|loanword)* on the F3 value of adapted structure. It was speculated that the null result is due to the narrow set of loanwords employed in the passage-reading task, as with the redundancy in imported structure. It is left for future work to explore a wider set of loanwords. On the other hand, it was found that the F3 value of adapted structure is affected by the predictability of the social message given a speaker. However, the direction is in the opposite direction from our prediction, i.e., adapted structure with *higher predictability* given a speaker is more likely to be pronounced with *lower* F3. As discussed in 6.6.3, we speculate that the exemplar-averaging process, which forms a production target, has a strong effect on the production of adapted structure, and consequently the effect of message-oriented articulatory biases is concealed. This theoretical interpretation is discussed in 8.2.2 and 8.3 in more depth.

In this way, the results reported in the current study partially provide evidence that the phonetic implementation of adapted structure and imported structure is affected by the predictability of choosing each variant. These findings develop our understanding of the relationship between the realization of a linguistic unit and the predictability of that unit in general. In what follows, we will clarify what these findings imply theoretically.

8.2 Overarching research question: cognitive process of loanword phonology

Let us now restate what sort of insight the above findings provide to our theoretical framework. Recall that our theoretical framework was developed based on Exemplar Theory (Pierrehumbert 2001; 2002) and MOP (Hall et al. 2016; 2018), see Figure 1.3. Our framework is constructed from a series of the hypotheses regarding how imported structure and adapted structure are stored in the mind of a borrower and processed in the production of a loanword. That is, the framework offers a potential answer to the overarching research question about the cognitive process of loanword production [RQ1]. In what follows, we will discuss how the hypotheses were supported by our findings about the two concrete research questions about [RQ1a] likelihood of adaptation vs. importation and [RQ1b] phonetic redundancy in adapted structure and imported structure, as wrapped up in the last section.

8.2.1 Representation and category activation

This section clarifies how our hypotheses were supported by addressing the research question about the likelihood of adaptation vs. importation [RQ1a]. This research question yields the four specific questions [RQ2-5], allowing us to assess the hypotheses about the representations of exemplars and categories (see 1.7.1) and the activation of a category (see

1.7.2).

First, let us discuss the robust topic effects on the likelihood of adaptation vs. importation [Prediction 2]. This effect provides the evidence that (1c) the social concept "Māori" is activated by a topic in speech, and (1b) the activation of imported structure is more likely to occur when the concept "Māori" is activated as we hypothesized that (0c) imported structure is closely associated with the social concept "Māori." Our theoretical interpretation is as follows (see also 3.5.1 and 5.5.1): speaking about Māori activates the social concept "Māori," and the representation of imported structure becomes likely to be activated via the socio-indexical link between imported structure and the social concept "Māori." Once the category of imported structure becomes likely to be activated further, the exemplars belonging to this category are more likely to be chosen. Consequently, imported structure is more likely to be produced in speech about Māori.

Second, we would like to discuss the cultural image effects on the likelihood of choosing a variant in loanword phonology [Prediction 3]. This effect could be predicted in a similar way to the topic effect, that is, by positing that (1c) the social concept "Māori" is activated by a presented Māori image, and that (1b) the activation of the social concept "Māori" raises the activation of the representation of imported structure via the socio-indexical link. As was discussed above, our results are tentative with regards to *cultural image*, although it shows a statistical trend in the predicted direction. This nuanced result implies that a cultural image is unlikely to affect the selection of a linguistic variant in production, and we might need to reconsider hypothesis (1c), that a presented cultural image activates the social concept "Māori." This raises a big question about the difference between topic effects and image effects. Why are topic effects robust but image effects are not? In 5.2.2, we speculated that this is due to the degree of consciousness. Alternating images may be less explicit in comparison to alternating topics in speech, because the exposure to a cultural image is subtle and it is not exactly a part of a speech act. Because of the different degrees of consciousness, the activation of the social category "Māori" is so strong given Māori topics that the linguistic category called imported structure is sequentially activated, while the activation of the social category is not so strong given a Māori image that the linguistic category is activated. Hence, topics change the importation rate significantly, but images do not. This speculation is illustrated in Figure 5.9, which is repeated as Figure 8.1.

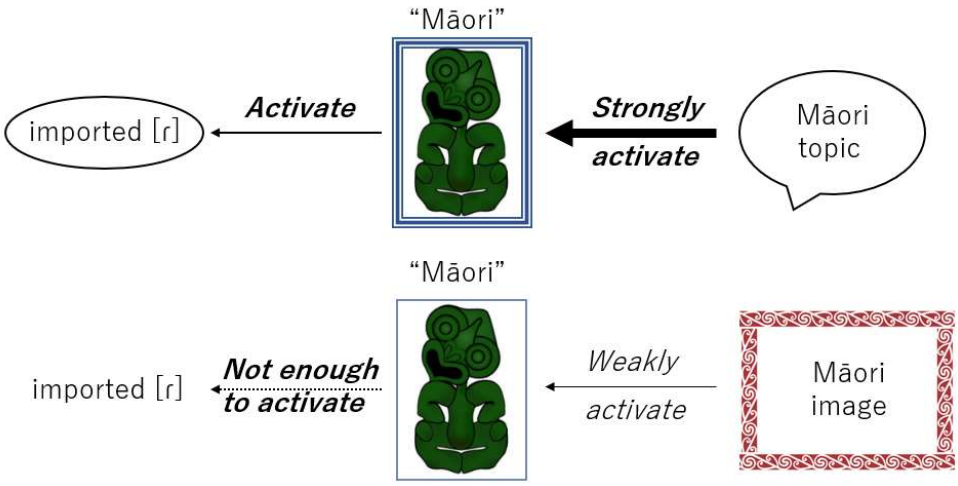

Figure 8.1 Difference in social category activation between topic and image

As reviewed in 4.2.2.1, Hay & Drager (2010) observed significant effects of cultural images on dialect perception. This raises another question: Why were cultural image effects observed in their study, but they are not observed in the current thesis? The reason might be that they explored gradient difference between vocalic variants (e.g., higher [ɪ] ⇔ lower [ɪ]), while the categories discussed in the current thesis have a discrete nature (i.e., tap [ɾ] vs. approximant [ɹ]). It could be speculated that shifts between discrete categories require stronger activation of categories in comparison to gradient shifts, because exemplars belonging to different discrete categories may not be stored so closely as those belonging to a gradient continuum. This may be one reason why alternating images did not significantly influence the likelihood of choosing a discrete variant in the current study.

Next, we consider the results about the speakers' association with the source language and its culture. As was discussed above, we explored specifically the effects of the speakers' relationship with Māori [Prediction 4a] and their attitudes towards Māori [Prediction 4b]. Our results show that both these factors affect the likelihood of adaptation vs. importation. First, the significant effects of the relationship support the hypothesis that (1a) the likelihood of activating adapted structure or imported structure potentially depends on the strength of the exemplars belonging to each category. Our theoretical interpretation is as follows (see 3.5.2 and 5.5.3): Speakers strongly related with Māori may be more likely to be exposed to imported structure and have more opportunities to store exemplars with imported structure. The more borrowers are exposed to exemplars with imported structure, the higher the potential strength of the exemplars with imported structure becomes. Consequently, imported structure is more likely to be produced by the speakers strongly related with Māori. Second, the significant attitude effect supports the hypotheses (1d) and (1b). The attitude effects can be captured by positing that (1d) speakers with more positive attitudes towards Māori activate the social concept "Māori," and that (1b) the activation of the social concept "Māori" raises the activation of the representation of imported structure. As it is assumed that (2a) an exemplar is chosen on the basis of the

activated category, these two hypotheses successfully derive the prediction that an exemplar with imported structure is more likely to be chosen by a speaker with more positive attitudes towards "Māori."

Finally, let us consider the theoretical interpretation of the effects of words' association with the source language and its culture on the likelihood of adaptation vs. importation [Prediction 5]. As restated in the preceding section, this effect is significant in the word-list reading task. The results provide the evidence for the hypothesis that (1a) the likelihood of activating adapted structure or imported structure potentially depends on the strength of the exemplars belonging to each category. Our theoretical interpretation is as follows (see 4.5.3): Imported structure may be heard more often in loanwords strongly associated with Māori in comparison with those weakly associated with Māori, because imported structure is used more often in a Māori community. Consequently, loanwords strongly associated with Māori may be more likely to be stored with imported structure in memory, and exemplars with imported structure will have higher strength amongst exemplars associated with the lexical categories. As it is hypothesized that (1a) a category represented by exemplars with higher potential strength is more likely to be activated, imported structure is more likely to be produced for loanwords strongly associated with Māori.

In this way, the results reported in this thesis are essentially in line with our theoretical framework. That is, the hypotheses about (0) the representations of exemplars and categories, and (1) the category activation, are well-supported in the current study. The results reported above provide evidence that the knowledge of loanword pronunciation is represented by exemplars and categories in relation to a social category, and the activation of adapted structure vs. imported structure depends on the strength of exemplars belonging to each category and the activation of the social concept "Māori."

8.2.2 Representation, averaging, and production biases

Next, we will clarify how our hypotheses were supported by addressing the research question about the relationship between redundancy in a variant and the social message predictability [RQ1b]. This research question leads to the two specific questions about redundancy in imported structure and adapted structure [RQ6-7]. The relevant hypotheses are about the representation of predictability (see 1.7.1), and the message-oriented articulatory biases (see 1.7.4). As was discussed in Chapter 7, these hypotheses cannot account for a part of our results in relation to adapted structure. It was speculated that the relationship between phonetic implementation and the predictability is strongly influenced by the exemplar-averaging process, and consequently the effect of articulatory biases may be concealed. Hence, we also discuss the assumption that exemplars are averaged to form a production target (see 1.7.3) in what follows.

First, let us discuss redundancy in imported structure. It was found that the duration of imported structure negatively correlates with the predictability of imported structure [ɾ] given

a loanword. This effect is as predicted [Prediction 6], and provides the evidence for (0d) the hypothesis about retrieving the probability given a loanword from the exemplar space and (3a-d) the hypotheses about message-based articulatory biases. Our message-oriented theoretical interpretation is as follows (see 6.6.1): When a speaker forms a production target from the exemplar space, (0d) she could retrieve the probability of imported structure as opposed to adapted structure given a loanword (i.e., p(ɾ|loanword)) based on the number of the exemplars associated with a particular lexical category. We hypothesize that (3c) this probability represents the predictability of (3a) the social message associated with Māori. In accordance with the signal modification principle (see 1.7.4), (3b) redundancy is reduced from a production target when its social message is more predictable given the context, and vice versa. Recall that speakers are hypothesized to use "the right sort of redundancy" to avoid "inefficient redundancy," and thereby augment "the likelihood of sufficiently accurate and cost-effective message transmission" (Hall et al. 2016). It is hypothesized that (3d) the redundancy of imported structure correlates with the duration (i.e., formant cessation), because longer formant cessation differentiates further imported structure from adapted structure, that is, it improves the signal specificity (see Figure 1.13). In consequence, imported structure with lower information content (i.e., higher predictability) is produced with shorter duration. This relationship is illustrated in Figure 6.11, which is repeated as Figure 8.2. The amount of redundancy in a signal varies in accordance with the predictability of the social message associated with Māori from context.

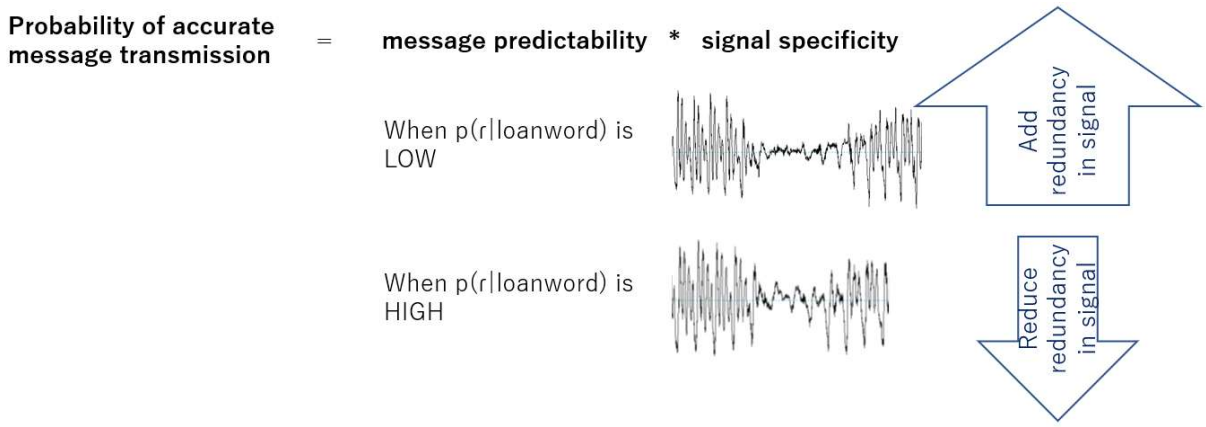

Figure 8.2 Signal specificity as a function of message predictability

On the other hand, it was not found that the predictability of imported structure [ɾ] given a speaker affects the redundancy in imported structure. In order to account for this null result, we speculated in 6.6.2 that it is difficult for a speaker to retrieve the probability of imported structure as opposed to adapted structure given a speaker (i.e., p(ɾ|speaker)). The reason for this difficulty is that this predictability could be retrieved by taking into account the overall number of exemplars with imported structure and adapted structure within the whole cognitive system. The calculation based on a larger number of exemplars might be more difficult in compared

with that based on a smaller number of exemplars. This implies that we need to discard or modify the hypothesis that (0e) the probability of imported structure as opposed to adapted structure given a speaker (i.e., $p(\text{ɾ}|\text{speaker})$) is retrievable based on the number of the exemplars within the cognitive system. Further exploration regarding speaker-specific predictability is left for future study.

In addition to these predictability effects, it was found that some sociolinguistic factors affect the redundancy in imported structure. More specifically, speakers with more positive attitudes towards Māori are likely to add more redundancy in the production of imported structure, and more redundancy is likely to be added to the production of imported structure when a topic in speech is associated with Māori, although the topic effect is a statistical trend (p=0.07). It was speculated in 6.6.3 that a speaker might emphasize a signal for her intended social message when she wishes to express the message strongly. A speaker with more positive attitudes towards Māori might wish to express her solidarity with Māori strongly, and a speaker might wish to express her association strongly when reading a Māori passage, see Audience Design (Bell 1984; 2001). In order to clearly express the social message associated with Māori, a speaker might attempt to improve the probability of accurate message transmission. In consequence, when a speaker wishes to express the social message associated with Māori more clearly, the speaker adds redundancy to a signal to improve the signal specificity, thereby increasing the accuracy; when a speaker does not wish to express the social message so strongly, the speaker reduces the redundancy in the production of a signal, thereby increasing the efficiency. This account is illustrated in Figure 6.12, which is repeated as Figure 8.3. Given that a speaker wishes to express her solidarity with Māori strongly, the enough probability of accuracy goes up, and accordingly signal specificity needs to be higher; given that a speaker weakly wishes to express her association with Māori, the enough probability of accuracy is not so high, and accordingly signal specificity could be low.

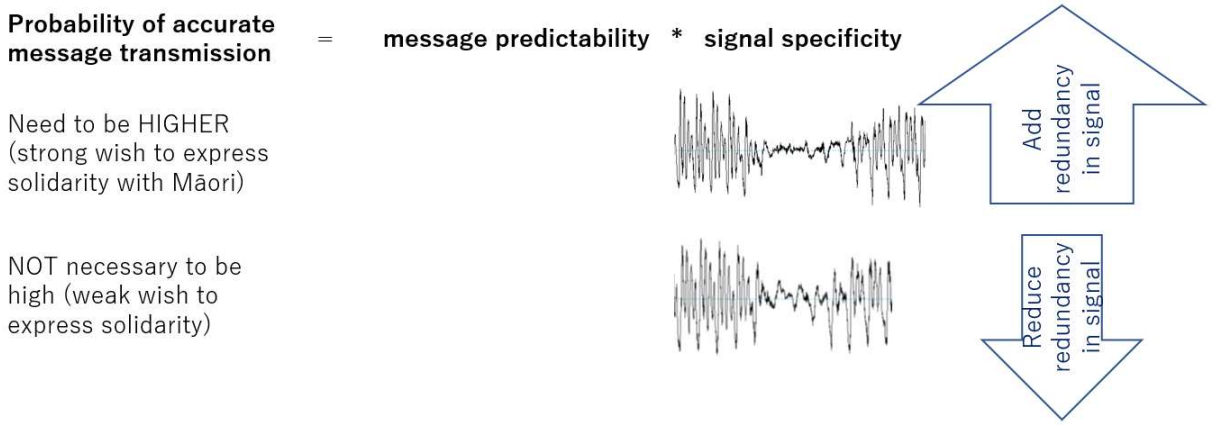

Figure 8.3 Signal specificity as a function of desired probability of accuracy

Next, we will discuss redundancy in adapted structure. Similarly to redundancy in

imported structure, it was predicted that redundancy is decreased in adapted structure with higher predictability, that is, the F3 value is not lowered in adapted structure with higher predictability [Prediction 7]. First, the effect of *p*(ɹ|loanword) was not found to be a significant predictor for the redundancy in adapted structure, that is, the formant value. It was speculated that this might be due to the experimental design, and it was pointed out that this effect should be explored using a larger set of loanwords in future studies. Next, it was found that the effect of *p*(ɹ|speaker) on a formant value of adapted structure is statistically significant, but the direction is opposite from our prediction, i.e., adapted structure with *higher predictability* given a speaker is more likely to be pronounced with *lower* F3. We believe that this result does not completely negate the hypotheses about message-oriented articulatory biases (3a-d), which are well-supported by the predictability effects on redundancy in imported structure. Rather, we interpret this result to mean that another part of our theoretical framework plays a dominant role in determining a production target, and the effect of the message-oriented articulatory biases is concealed.

As discussed in 7.5.3, the alternative account is based on the exemplar-averaging process. Following previous literature (Pierrehumbert 2001; 2002; Wedel 2006), it is assumed in the current study that a production target is formed by (2a) choosing an exemplar belonging to the activated category and (2c) averaging the exemplar with the surrounding exemplars. That is, a production target is formed on the basis of several exemplars before it undergoes the message-oriented production biases (see Figure 1.3). With respect to formant values, we could posit that an exemplar with [ɹ] is stored with a relatively lower F3 value and an exemplar with [ɾ] is stored with a null F3 value. As long as formant structure could be averaged through the process of averaging a target exemplar with surrounding exemplars, our theoretical framework can account for the observed effect of *p*(ɹ|speaker) on formant structure of approximants. That is, it predicts that adapted structure with *higher predictability* is produced with *lower* F3, because a target exemplar is more likely to be averaged with surrounding exemplars with lower F3 values (i.e., adapted structure), when adapted structure is more predictable given a speaker, that is, when a larger number of exemplars with adapted structure are stored within a cognitive system. This is demonstrated in Figures 7.7 and 7.8, which are repeated as Figures 8.4 and 8.5 respectively. Figure 8.4 shows that, when a higher number of exemplars with adapted structure are stored, exemplars with adapted structure are more likely to be averaged with adapted structure, and vice versa. Figure 7.7 postulates that *SpeakerX* stores 750 exemplars with imported structure and 250 exemplars with adapted structure, with the reverse being postulated for *SpeakerY*. The bold-circled letter represents an exemplar that is picked up as a target exemplar, and the other circled letters represent surrounding exemplars that are selected additionally. Because of the number of exemplars with particular variants, a target exemplar with adapted structure is more likely to be averaged with surrounding exemplars with adapted structure, when the higher number of exemplars with adapted structure are represented in a cognitive system, and vice versa.

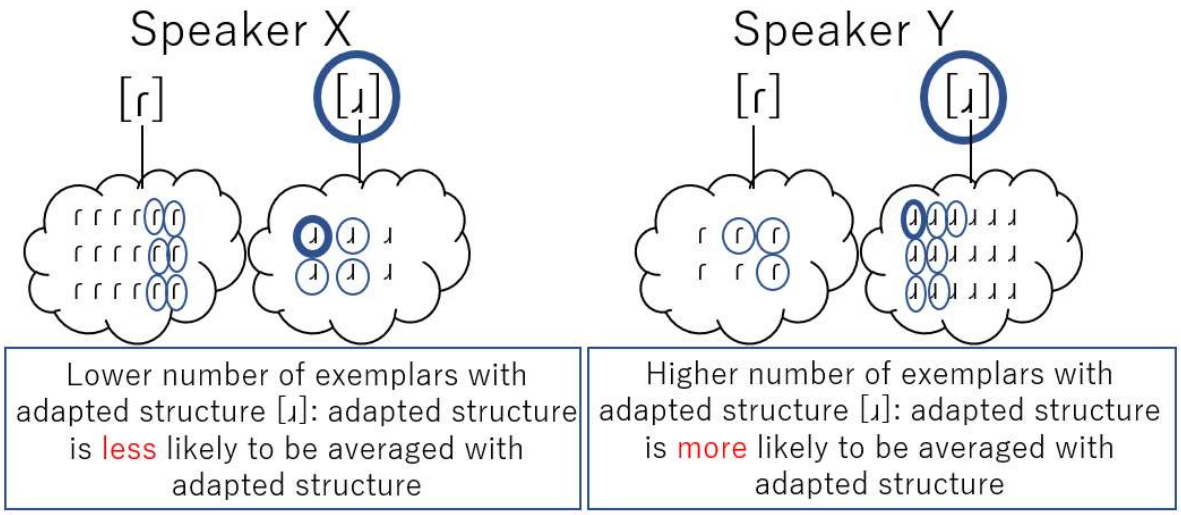

Figure 8.4 Averaging of exemplars with adapted structure and imported structure

Figure 8.5 illustrates what the outcome of averaging exemplars with adapted structure and imported structure would be like. The red line indicates F3 transitions, and the absence of the line indicates lack of formant structure. The box represents the range of phonetic variability in adapted structure [ɹ]. When an exemplar with adapted structure is averaged with a larger number of exemplars with adapted structure, it is produced with typical formant structure, that is, a lower F3 value (as shown to the right in Figure 8.5); when it is averaged with a larger number of exemplars with imported structure, it is produced with atypical formant structure, that is, a non-lowered F3 value (as shown to the left, inside the box, in Figure 8.5).

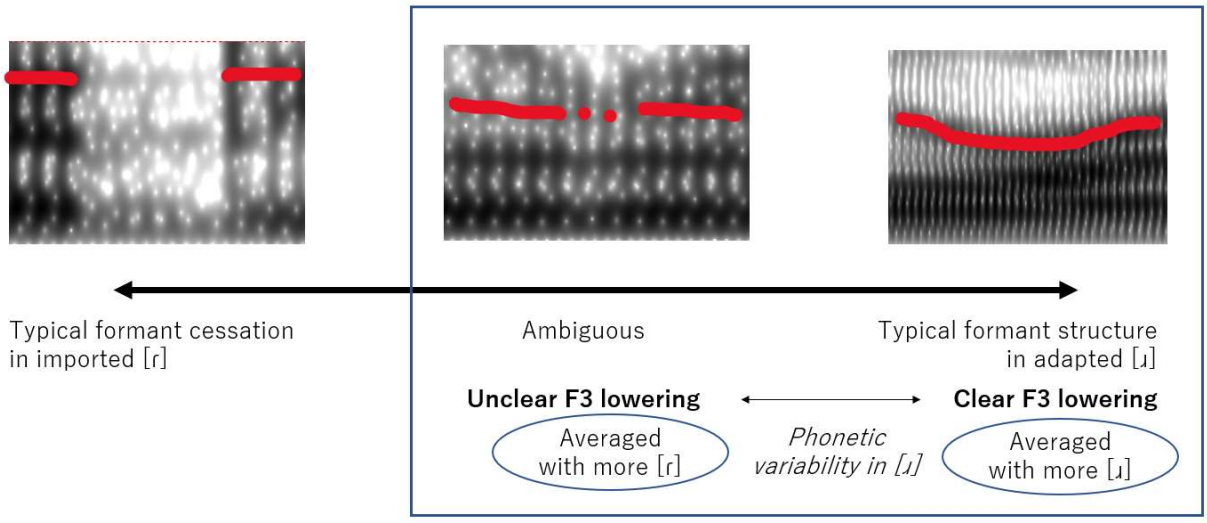

Figure 8.5 Phonetic variability in adapted structure

These predictions are simulated in Figure 7.9. As discussed above, the effect of *p*(ɹ|loanword) was not found to be significant on F3 values of adapted structure, and it was speculated that this might be due to the small set of loanwords employed in the passage-reading task. Note that the direction is the same for *p*(ɹ|speaker): that is, there is a tendency that adapted structure with

higher predictability given a loanword is produced with lower F3 values. If this loanword-given predictability is found to be significant in future studies exploring a larger set of loanwords, the effect could be captured by positing that exemplars are averaged to determine a production target, as discussed above.

In summary, our results in relation to imported structure redundancy [RQ6] are in line with the hypotheses about (0d) word-specific predictability and (3a-d) the message-oriented articulatory biases, but are nuanced with respect to the hypothesis about (0e) speaker-specific predictability. On the other hand, the results in relation to adapted structure contradict the prediction deduced from the hypotheses about the message-oriented articulatory biases. An alternative account is offered by positing that the formant values of a target exemplar and the surrounding exemplars can be averaged to determine a production target. That is, the data reported in the current study provides evidence that a speaker could retrieve the predictability from the exemplar space, and a production target is determined by both the exemplar-averaging process and the articulatory biases, as illustrated in our theoretical framework (see Figure 1.3). There is a remaining question: Why would adapted structure be affected by the exemplar-averaging process, but imported structure be influenced by the message-oriented articulatory biases? This question was discussed in 7.5.3, and it is restated in the following section in more depth.

8.3 Wider implications: message-oriented biases vs. exemplar averaging

The goal of this section is to compare the predictions of message-oriented biases and exemplar averaging in tandem, and discuss the wider implications for linguistic variation in general. As explained above, the results in relation to redundancy in imported structure and adapted structure could be captured by positing that imported structure is more likely to be affected by the message-oriented articulatory biases, and adapted structure is more likely to be affected influenced by the exemplar-averaging process.[15] It was speculated in 7.5.3 that the reason is that the social message carried by imported structure is salient in New Zealand society, while the message carried by adapted structure is neutral or non-salient. The imported structure [ɾ] is not a native structure, and so may carry a strong social message: It may explicitly express solidarity with Māori. On the other hand, the adapted structure [ɹ] is a native structure and widely used in the English lexicon, and thus the social message is likely neutral: Speakers may not be able to explicitly express a social message dissociated from Māori.

In sum, our updated hypothesis is that the realization of a linguistic variant is more likely to be affected by a different part of the production-perception loop depending on the saliency

[15] As stated in 7.5.3, we do not claim that imported structure is affected only by articulatory biases and adapted structure is affected only by exemplar-averaging processes. Rather, we assume that the two structures are affected by the two mechanisms, and the degree of influence of each mechanism differs between the two structures depending on the saliency of the social message.

of the social message, i.e., it is likely to be more affected by exemplar-averaging processes when the social message is neutral or non-salient, while it is likely to be more affected by message-oriented articulatory biases when the social message is strong or salient. In the case of NZE loanword phonology, this hypothesis is illustrated in Figures 8.6 and 8.7. As with Figure 1.13, the red line indicates the transition of F3. The red arrows represent a direction of modification guided by message-oriented biases, while the blue arrows indicate those guided by exemplar-averaging processes. The circles indicate which mechanism each variant actually obeys. Figure 8.6 illustrates the realization of a variant with *lower* predictability, while Figure 8.7 illustrates the realization of a variant with *higher* predictability. Recall that message-oriented biases may influence a variant to be different further from the other variant when it is less predictable from context, thereby improving signal specificity and the accuracy of the social message transmission. Exemplar-averaging processes render a variant (e.g., adapted structure) similar to the other variant (e.g., imported structure) when there are smaller number of exemplars with the variant (e.g., adapted structure). This is because a target exemplar with the variant is likely to be averaged with surrounding exemplars with the other variant. As imported structure [ɾ] carries a salient social message, it is more likely to be affected by the message-oriented articulatory biases. Therefore, the formant cessation becomes clearer in imported structure with lower predictability. On the other hand, adapted structure [ɹ] carries non-salient social messages, and thus it is more likely to be affected by the averaging processes, with the result that the F3-lowering becomes less clear in adapted structure with lower predictability.

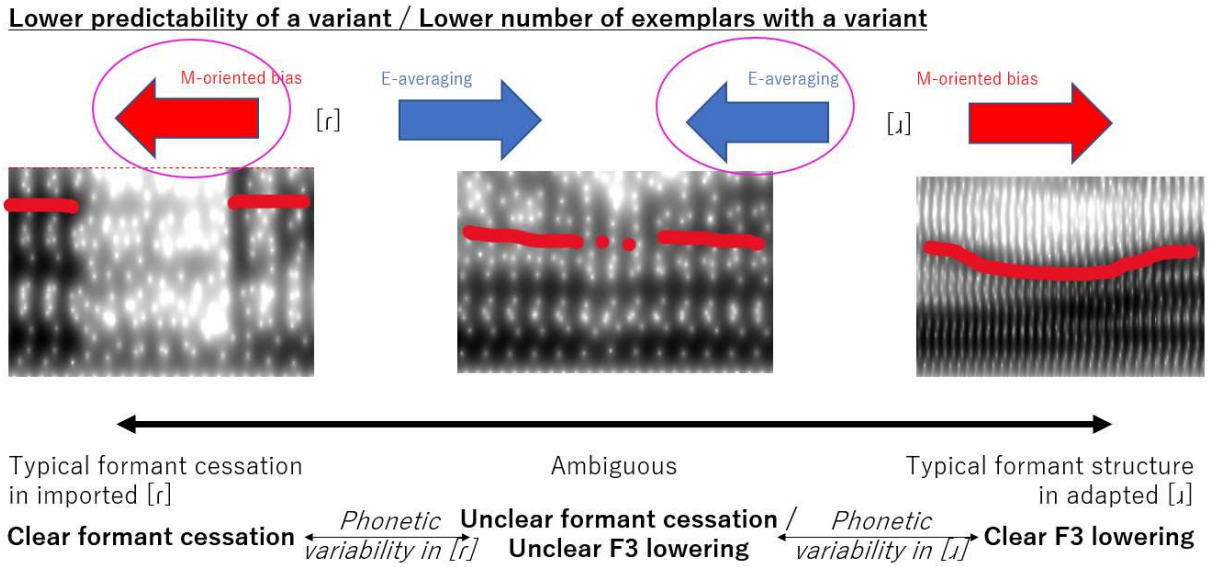

Figure 8.6 Message-oriented biases vs. exemplar averaging given low predictability (Red arrow indicates message-oriented direction; Blue arrow indicates exemplar-averaging direction; Circle indicates observed direction; Red line shows F3 transition)

In regards to variants with *higher* predictability, recall that message-oriented biases may

influence a signal to have less clear acoustic cues when the message is more predictable from context, thereby decreasing resource cost. Exemplar-averaging processes render a variant to be distinct from the other variant when there are a larger number of exemplars with the variant. This is because a target exemplar with the variant is likely to be averaged with surrounding exemplars with the variant. As imported structure [ɾ] carries a salient social message, it is more likely to be affected by the message-oriented articulatory biases, and the formant cessation becomes less clear in imported structure with higher predictability. On the other hand, adapted structure [ɹ] carries non-salient social messages, and thus it is more likely to be affected by the averaging processes, the result of which is that the F3-lowering becomes clearer in adapted structure with higher predictability.

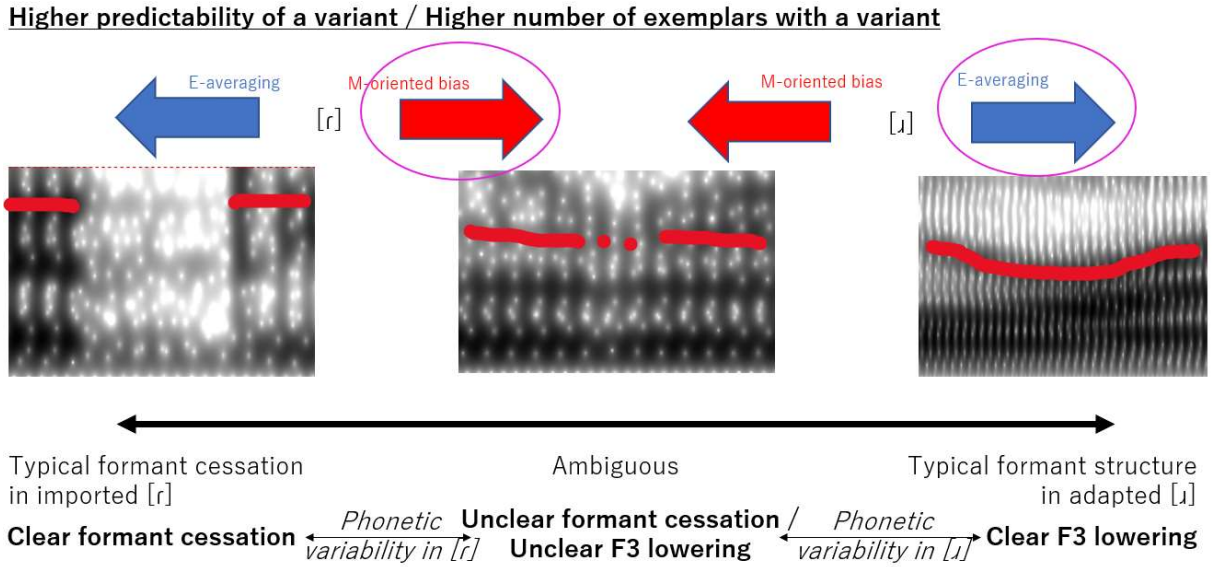

Figure 8.7 Message-oriented biases vs. exemplar averaging given high predictability

In this way, the two variants [ɾ] and [ɹ] are affected by the different parts of the production-perception loop (i.e., message-oriented biases and exemplar-averaging processes) depending on the saliency of their social messages.

It goes without saying that this updated hypothesis needs to be tested in future study. NZE may provide an interesting test case for the hypothesis. In NZE, intervocalic voiceless plosives /p, t, k/ (e.g., *copper*, *butter*, and *bacon*) are sometimes produced with incomplete closure, that is, realized as fricated variants [p̬, t̬, k̬], especially in unstressed syllables (Taylor 1996; Fiasson 2015; Hashimoto & Hume 2018).[16] The previous literature points out that the likelihood of choosing the variant (e.g., [t] vs. [t̬]) depends on sociolinguistic factors such as speech style (formal vs. casual) and gender (male vs. female). That is, this variation may be socially

[16] Note that fricated variants of voiceless plosive phonemes have been observed in other varieties of English as well: Australian English (Jones & McDougall 2009; Loakes & McDougall 2010); Liverpool English (Honeybone 2001); RP English (Buizza & Plug 2012).

meaningful, and the variants may carry particular social messages as in other sociolinguistic variation. The major difference of a released variant [t] from a fricated variant [t̪] is the presence of a burst with a closure phase and a release phase, and the major difference of a fricated variant [t̪] from a released variant [t] is the continuation of aperiodic noise. As shown in Figure 8.8, it could be assumed that a fricated variant with longer aperiodic noise is typical and likely to be identified as [t̪] correctly, and a released variant with longer closure and release phases is typical and likely to be identified as [t] correctly. This is because each sound possesses key acoustic cues to each variant. On the other hand, a fricated variant with shorter aperiodic noise may be a little ambiguous and therefore hard to identify as [t̪], and a released variant with shorter closure and release phases may also be a little ambiguous. The reason for the ambiguity is that they lack clear acoustic cues to each variant. Our updated hypothesis deduces the following predictions: If a variant [t̪] carries a salient social message, then it should be produced with shorter duration when it is predictable from contexts. This is because it should be affected further by the message-oriented biases, and less redundancy is added to the signal to decrease resource cost, with the result that it is produced with less clear aperiodic noise. If a variant [t̪] carries a non-salient social message, then it should be produced with longer duration when it is predictable from contexts (i.e., a variant [t̪] is stored more often in comparison to the other variant [t]). This is because it should be influenced further by the exemplar-averaging processes, and a target exemplar with [t̪] is averaged with surrounding exemplars with [t̪], the result of which is that it is produced with clearer aperiodic noise. Likewise, the duration of [t] may also be affected by the predictability, and the direction depends on the saliency of the social message.

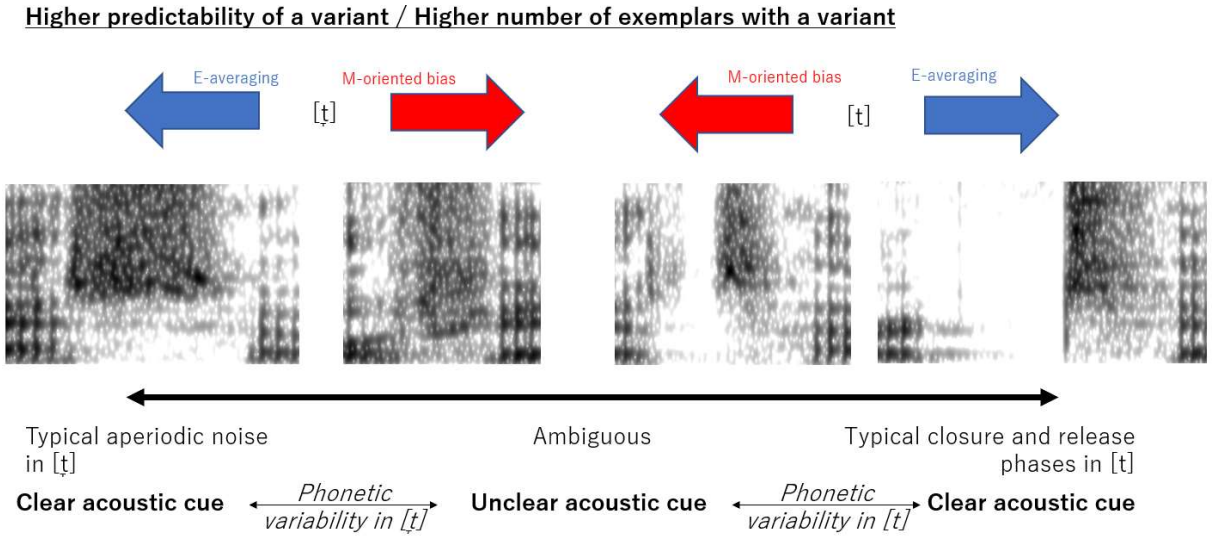

Figure 8.8 Message-oriented and averaging-based prediction about /t/

Further exploration regarding how a sociolinguistically meaningful variant is realized in relation to the predictability of choosing the variant will provide further information about the relationship between the realization of a linguistic unit and its predictability.

8.4 Limitations and future research

This section points out future research areas and remaining issues. At a descriptive level, the current study draws on the observation that /r/ sounds in Māori loanwords can be pronounced as imported rhotic sounds [ɾ] or adapted rhotic sounds [ɹ] in NZE. However, the variation in the Māori loanword pronunciation is more than the production of [ɹ]. As pointed out in 1.6, vowels seem to be pronounced in a variety of ways. Māori vowels may be adapted to native English vowels, but they may also be imported and pronounced with different formant values than the native vowels. In addition, there is a possibility that the phonological categories that exist in English, such as /p, t, k/, could be realized with different phonetic values in Māori loanwords, that is, some consonants might be imported at the phonetic levels. Further exploration regarding how phonological categories other than /r/ are phonetically realized in Māori loanwords will offer a more comprehensive picture of how NZE speakers pronounce Māori loanwords.

The current study demonstrates that the variation in loanword phonology depends on sociolinguistic factors. As was reviewed in 1.3, there are a limited number of previous studies that discuss loanword phonology in relation to sociolinguistic factors, and there still remains a variety of sociolinguistic factors unexplored. For example, little is known about a diachronic change in loanword phonology, to the best of our knowledge (but see Friesner 2009). NZE loanword phonology may provide an interesting test case to explore this effect, because te reo Māori is promoted in society these days, and a larger number of New Zealanders are exposed to the usage and more interested in the language. That is, the attitudes towards te reo Māori and the relationships with te reo Māori have been changing in the society (Te Puni Kōkiri 2009). It would be interesting to compare the pronunciations between younger speakers and older speakers.

Cultural image effects were well-attested by Hay & Drager (2010) in relation to dialect perception, and thus we expected that they should be extended to the production of linguistic variants. However, our results were nuanced with respect to the effects of cultural images on the production of linguistic variants. We speculated that this is because of the nature of variation. The variants discussed in their study belong to a gradient continuum (e.g., higher [ɪ] ⇔ lower [ɪ]) whereas the variants discussed in the current study have a discrete nature (i.e., tap [ɾ] vs. approximant [ɹ]). In future work, it is worth testing whether the cultural image effect extends to the production of linguistic variants by exploring variations with a gradient nature.

As was reviewed in 1.4, it has been demonstrated by previous literature that a linguistic signal is phonetically (i.e., acoustically and articulatorily) reduced in accordance with the predictability of the lexical message that the signal conveys. The current study has extended the findings of previous literature from lexical message predictability to social message predictability. As pointed out in the preceding section, the further exploration of the social message predictability effect on redundancy in linguistic variants will provide an insight to social message transmission, as a variety of variations have been considered sociolinguistically

meaningful (Bell 2014; Eckert 2016).

Finally, we would like to discuss exemplar averaging. It was speculated in the current study that an exemplar with a given variant (e.g., adapted structure) could be averaged with surrounding exemplars with another variant (e.g., imported structure) to determine the production target. This mechanism has been posited in previous literature (Pierrehumbert 2001; 2002; Wedel 2006) to represent a variation-narrowing mechanism (see 1.7.3), but it has not often been discussed empirically in relation to phonetic implementation (but see Hay & Maclagan 2012). This hypothesis should be tested by exploring other linguistic variations. That is, it would be interesting to explore how the pronunciation of a linguistic variant is affected by the phonetic properties of other linguistic variants: what kind of phonetic values could be averaged to determine a production target (e.g., formant structure, centre of gravity, and segmental duration), and in what domain exemplars could be averaged (e.g., word-specific domain and speaker-specific domain)? Whether this averaging process affects higher linguistic levels such as words and syllables remains a question.

8.5 Conclusion

This thesis has studied the pronunciation of loanwords borrowed from te reo Māori to NZE. Our interest especially lies in the variation of /r/ realizations, that is, adapted structure [ɹ] vs. imported structure [ɾ]. Studying the variation has increased our knowledge of loanword phonology and linguistics in general, and informed the understanding of the cognitive process of loanword phonology.

The first part of the current study (Chapters 3-5) explored the effect of some sociolinguistic factors on the likelihood of choosing adapted structure vs. imported structure, by running three experiments. It was found that the selection of a variant in loanword phonology is affected by some sociolinguistic variables such as topics in speech, and speakers' and words' association with the source language and its culture. These findings increased our understanding of the relationship between loanword phonology and sociolinguistic variables, which has been less studied in previous literature. The results could be captured by positing that exemplars with adapted structure and imported structure are represented, the exemplar space is developed through the usage of loanwords, and the representation of imported structure is stored in relation to a social category "Māori." As the variation was found to be a type of inter-speaker and intra-speaker variation, it could be considered socially meaningful as in other sociolinguistic variation. Namely, imported structure and adapted structure carry different social messages. In particular, it is argued that imported structure has a social message associated with Māori.

On the basis of this argument, the second part of this thesis (Chapters 5-6) explored the relationship between the realization of a variant and the social message predictability. It was found that the redundancy in the two variants (i.e., [ɾ] and [ɹ]) is both affected by the predictability of choosing a variant to some extent. However, the direction was found to be different between the two variants: imported structure with higher predictability is likely to be

realized with *lower* redundancy (i.e., shorter formant cessation) while adapted structure with higher predictability is likely to be realized with *higher* redundancy (i.e., lower F3 value). This result is interpreted to mean that imported structure is likely to be affected strongly by message-oriented biases, because the structure is specific to loanwords and the social message is likely salient. On the other hand, we speculated that adapted structure is likely to be affected strongly by exemplar-averaging processes, because the social message is likely non-salient. This discussion develops our understanding of the relationship between the realization of a linguistic unit and the predictability in general.

Appendix A: Code to generate Figure 1.8

```
library(ggplot2)
# Generate 1000 numbers from a normal distribution, whose mean and sd are 1000 and 100.
# These numbers are regarded as phonetic values of exemplars at the initial state.
# This exemplar cloud is called "Initial."
Initial <- rnorm(1000, mean=1000, sd=100)
# Pick up 10 exemplars from the exemplar cloud, and average the values to form production targets.
# The production targets formed through this averaging process are stored as new exemplars.
# Run this averaging process 100 times.
# This exemplar cloud is called "Hundred."
Hundred <- Initial
for(i in 1:100){
   Hundred<-sample(Hundred)
   new<-mean(Hundred[1:10])
   Hundred[1000+i]<-new
}
# Pick up 10 exemplars from the exemplar cloud, and average the values to form production targets.
# The production targets formed through this averaging process are stored as new exemplars.
# Run this averaging process 1000 times.
# This exemplar cloud is called "Thousand."
Thousand <- Initial
for(i in 1:1000){
   Thousand<-sample(Thousand)
   new<-mean(Thousand[1:10])
   Thousand[1000+i]<-new
}
# Plot the three exemplar clouds together in a figure.
value<-c(Initial, Hundred, Thousand)
A<-rep("Initial", 1000)
B<-rep("Hundred", 1100)
C<-rep("Thousand", 2000)
times<-c(A, B, C)
data<-data.frame(value, times)
data$times = factor(data$times,levels(data$times)[c(2, 1, 3)])
ggplot(data, aes(value, fill=times, colour=times))+geom_density(alpha=0.2)+theme(text =
      element_text(size = 17))+xlab("formant value")
```

Appendix B: Advertisements

Are you a Pākehā speaker of New Zealand English?

Reward: $15 Westfield Voucher

Duration: Around 30 Minutes

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Kia ora. Nice to meet you. My name is Daiki Hashimoto.
I am a PhD student in Linguistics, and study New Zealand English. In my PhD project, I am looking for Pākehā speakers of New Zealand English.

If you are a native Pākehā speaker of New Zealand English aged 18 to 35 years, born and raised in New Zealand and you are not a fluent speaker of another language, I welcome your participation.

The aim of this study is to understand how certain words are said in New Zealand English. This research will clarify strategies used in saying certain words and the effect of some social factors on the words.

If you choose to participate in this study, you would be invited to come to a sound-attenuated room at the University of Canterbury. Then, you will be asked to read sentences. Each sentence will be presented on the computer screen for you to say, and they will be recorded. After the experiment, you will be asked to answer some questions about your background.

The experiment will take around 30 minutes.

Any information that you will provide in this experiment will remain confidential and will be used only for the purposes of this study.

You will receive a $15 Westfield Voucher for your participation. If you are interested in helping, please contact Daiki Hashimoto at dha114@uclive.ac.nz (preferred), or contact 022-0965891. (This research is conducted by a PhD student in linguistics and has received University of Canterbury Human Ethics Committee approval.)

Appendix C: Questionnaires

Page 1

_____ (participant number)

QUESTIONNAIRE

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

In the questionnaire you will be asked how connected you are to Māori culture, and asked about the knowledge of Māori words.
The questionnaire consists of four parts. In the first part we will collect some information on your social background such as your age, place of birth, places they have lived and the proficiency in other languages. We need this information to make sure that you are a young adult speaker of New Zealand English. In the second part we would collect some information about your familiarity with Māori language and culture. In the third part we would collect information about how often Māori words are used in your daily speech. In the fourth part you will be asked to answer how strongly you think a Māori word is associated with Māori.
The collected data will be used for statistical analyses only and will not (and cannot) be linked to you personally. Do not include your name or contact details. Thanks for taking part in our study.

1. Background Information

Please fill in the following blanks.

Age: _____

Sex: _____

City of birth: _____

Cities where you have lived:

_____ (_____ years)

_____ (_____ years)

_____ (_____ years)

_____ (_____ years)

Languages you speak:

Language you speak when you were a child at home: _____

Language you speak now (for each language indicate your proficiency beginner, intermediate, fluent):

(_____) _____

(_____) _____

I identify myself as Māori: YES NO

2. Familiarity with Māori language, people and culture

A. How often do you do the following? Please mark anywhere along the horizontal line. (adapted from Te Puni Kōkiri (2009) and Te Manatū Taonga (2009))

a. Greet in Māori

Very Seldom _____ Very Often

b. Watch Māori language TV programs

Very Seldom _____ Very Often

c. Access websites that contain Māori language resources

Very Seldom _____ Very Often

d. Attend ceremonies or events with Māori welcomes and speeches

Very Seldom _____ Very Often

e. Visit Māori art, culture or historical exhibits

Very Seldom _____ Very Often

f. Go to Kapa haka or Māori culture group concerts

Very Seldom _____ Very Often

g. Go to a marae

Very Seldom _____ Very Often

h. Access websites about Māori culture

Very Seldom _____ Very Often

B. How strongly do you agree to the following questions? Please mark anywhere along the horizontal line. (adapted from Te Puni Kōkiri (2009) and Te Manatū Taonga (2009))

a. Well spoken Māori is beautiful to listen to.

Strongly Disagree _____ Strongly Agree

b. It is OK for people to greet others in Māori.

Strongly Disagree _____ Strongly Agree

c. It is a good thing that Māori people speak Māori in public places, such as in the street or supermarket.

Strongly Disagree _____ Strongly Agree

d. I have a lot of respect for people who can speak Māori fluently.

Strongly Disagree _____ Strongly Agree

e. Some Māori language education should be compulsory in school for all children.

Strongly Disagree _____ Strongly Agree

f. Māori cultures and activities are an important part of NZ's national identity.

Strongly Disagree _____ Strongly Agree

g. It is important to learn about Māori culture.

Strongly Disagree _____ Strongly Agree

h. Māori cultural activities should receive some funding from Government.

Strongly Disagree _____ Strongly Agree

C. What percentage of the people you associate with are from following groups:

What is the percentage of the population of the following people surrounding you?

a. Māori relatives. (%)
b. Māori friends in daily life. (%)
c. Māori friends in online SNS. (%)
d. Māori classmates. (%)
e. Māori neighbors or flatmates. (%)
f. Relatives who can speak Māori. (%)
g. Friends in daily life who can speak Māori. (%)
h. Friends in SNS who can speak Māori. (%)
i. Classmates who can speak Māori. (%)
j. Neighbors who can speak Māori. (%)

D. How well are you able to speak Māori in everyday conversation? Please select one of the following five choices. (adapted from Te Puni Kōkiri (2009) and Te Manatū Taonga (2009))

1 Very well (I can talk about almost anything in Māori)
2 Well (I can talk about many things in Māori)
3 Fairly well (I can talk about some things in Māori)
4 Not very well (I can only talk about simple/basic things in Māori)
5 No more than a few words or phrases

E. If you have studied te reo Māori before, please explain your experience briefly (e.g. at elementary school, Māori 101, attending a cultural class).

_____

3. Frequency of Māori loanwords.

How often do you use or hear the following Māori words in your daily speech?

Please mark anywhere along the horizontal line.

1. Akaroa
   Very Seldom _____ Very Often
2. Aoraki
   Very Seldom _____ Very Often
3. Aotearoa
   Very Seldom _____ Very Often
4. Haere mai
   Very Seldom _____ Very Often
5. harakeke
   Very Seldom _____ Very Often
6. Kaikoura (Kaikōura)
   Very Seldom _____ Very Often

7. kakapo (kākāpō)
Very Seldom ——— Very Often
8. kakariki (kākāriki)
Very Seldom ——— Very Often
9. katipo (katipō)
Very Seldom ——— Very Often
10. kauri
Very Seldom ——— Very Often
11. Kia ora
Very Seldom ——— Very Often
12. koru
Very Seldom ——— Very Often
13. kumara (kūmara)
Very Seldom ——— Very Often
14. Maori (Māori)
Very Seldom ——— Very Often
15. Maruia
Very Seldom ——— Very Often
16. Matariki
Very Seldom ——— Very Often
17. marae
Very Seldom ——— Very Often
18. Moeraki
Very Seldom ——— Very Often
19. moko
Very Seldom ——— Very Often
20. Oamaru
Very Seldom ——— Very Often
21. Paeroa
Very Seldom ——— Very Often
22. Porirua
Very Seldom ——— Very Often
23. pukeko (pūkeko)
Very Seldom ——— Very Often
24. Rangi
Very Seldom ——— Very Often
25. Rangiora
Very Seldom ——— Very Often
26. Rangitoto
Very Seldom ——— Very Often

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27. Rotorua
Very Seldom ——— Very Often
28. rata (rātā)
Very Seldom ——— Very Often
29. rimu
Very Seldom ——— Very Often
30. tarakihi
Very Seldom ——— Very Often
31. Taranaki
Very Seldom ——— Very Often
32. Taupo (Taupō)
Very Seldom ——— Very Often
33. Tauranga
Very Seldom ——— Very Often
34. Tekapo
Very Seldom ——— Very Often
35. te reo
Very Seldom ——— Very Often
36. Timaru
Very Seldom ——— Very Often
37. Tokoroa
Very Seldom ——— Very Often
38. tuatara
Very Seldom ——— Very Often
39. Waikato
Very Seldom ——— Very Often
40. Waimairi
Very Seldom ——— Very Often
41. Waimakariri
Very Seldom ——— Very Often
42. Wairoa
Very Seldom ——— Very Often
43. Waitomo
Very Seldom ——— Very Often
44. Whangarei
Very Seldom ——— Very Often

Page 6

4. Association of each loanword with Māori

How strongly do you think the following words are associated with Māori? (Some words are associated with Māori very strongly. For example, I feel that *takahē* is not strongly associated with Māori but *hāngi* is more strongly associated with Māori.) Please mark anywhere along the horizontal line.

1. Akaroa
   Very Weakly _____ Very Strongly
2. Aoraki
   Very Weakly _____ Very Strongly
3. Aotearoa
   Very Weakly _____ Very Strongly
4. Haere mai
   Very Weakly _____ Very Strongly
5. harakeke
   Very Weakly _____ Very Strongly
6. Kaikoura (Kaikōura)
   Very Weakly _____ Very Strongly
7. kakapo (kākāpō)
   Very Weakly _____ Very Strongly
8. kakariki (kākāriki)
   Very Weakly _____ Very Strongly
9. katipo (katipō)
   Very Weakly _____ Very Strongly
10. kauri
    Very Weakly _____ Very Strongly
11. Kia ora
    Very Weakly _____ Very Strongly
12. koru
    Very Weakly _____ Very Strongly
13. kumara (kūmara)
    Very Weakly _____ Very Strongly
14. Maori (Māori)
    Very Weakly _____ Very Strongly
15. Maruia
    Very Weakly _____ Very Strongly
16. Matariki
    Very Weakly _____ Very Strongly
17. marae
    Very Weakly _____ Very Strongly

18. Moeraki
    Very Weakly _____ Very Strongly
19. moko
    Very Weakly _____ Very Strongly
20. Oamaru
    Very Weakly _____ Very Strongly
21. Paeroa
    Very Weakly _____ Very Strongly
22. Porirua
    Very Weakly _____ Very Strongly
23. pukeko (pūkeko)
    Very Weakly _____ Very Strongly
24. Rangi
    Very Weakly _____ Very Strongly
25. Rangiora
    Very Weakly _____ Very Strongly
26. Rangitoto
    Very Weakly _____ Very Strongly
27. Rotorua
    Very Weakly _____ Very Strongly
28. rata (rātā)
    Very Weakly _____ Very Strongly
29. rimu
    Very Weakly _____ Very Strongly
30. tarakihi
    Very Weakly _____ Very Strongly
31. Taranaki
    Very Weakly _____ Very Strongly
32. Taupo (Taupō)
    Very Weakly _____ Very Strongly
33. Tauranga
    Very Weakly _____ Very Strongly
34. Tekapo
    Very Weakly _____ Very Strongly
35. te reo
    Very Weakly _____ Very Strongly
36. Timaru
    Very Weakly _____ Very Strongly
37. Tokoroa
    Very Weakly _____ Very Strongly

38. tuatara

Very Weakly ——— Very Strongly

39. Waikato

Very Weakly ——— Very Strongly

40. Waimairi

Very Weakly ——— Very Strongly

41. Waimakariri

Very Weakly ——— Very Strongly

42. Wairoa

Very Weakly ——— Very Strongly

43. Waitomo

Very Weakly ——— Very Strongly

44. Whangarei

Very Weakly ——— Very Strongly

Appendix D: Old passages (used in Experiments 1 and 3)

Neutral A: Traveling from Auckland Airport

Many travellers start their trip around New Zealand at Auckland Airport. If you drive south from Auckland Airport, you can get to *Rotorua* in about 3 hours. There are thermal pools and geysers in the *Rotorua* area, and they are popular with tourists. If you drive another two hours, you can get to *Taranaki* or Napier. There is a beautiful mountain in the *Taranaki* region, and there are scenic beaches in Napier as well. If you do not want to drive so much, it only takes an hour to go to *Whangarei* from Auckland Airport. There are stylish cafes and restaurants in *Whangarei* City, and you can enjoy the Northland lifestyle. Auckland airport is a convenient springboard from which many fun destinations can be reached.

[References]

100% Pure New Zealand (n.d.) Whangarei. Retrieved July, 2017, from
http://www.newzealand.com/in/whangarei/

Taranaki like No Other (n.d.) Retrieved July, 2017, from
http://visit.taranaki.info/visit/news/featured/secret-paradise.aspx

Neutral B: Traveling from Christchurch

You can access various attractive locations from Christchurch. You can see penguins and seals in *Akaroa* and *Kaikoura* in the Summer. You can drive to *Akaroa* in only an hour, or to *Kaikoura* in three hours. Many people visit there to enjoy the nature. If you head southwards from Christchurch, you can go to the Otago region, which includes the *Moeraki* boulders and Dunedin. Fishing is popular on the *Moeraki* peninsula. If you head westward from Christchurch, you can reach *Aoraki* in around 4 hours. You can enjoy skiing on *Aoraki* in Winter, and there are many hiking tracks enabling you to explore the mountain in Summer.

Neutral C: Ocean Activity in New Zealand

There are lots of ways to enjoy New Zealands nature. For example, there are beautiful beaches that can be visited in the Bay of Plenty including in *Tauranga* and Maketu. There are many cruise ships that arrive in *Tauranga* Harbour from overseas. The South Island also has beautiful beaches; one of them being in the *Timaru* District. You can also enjoy beach volleyball, mini golf, and many activities there. If you drive from *Timaru* southward, you can reach *Oamaru* in an hour. You can see blue penguins in *Oamaru* at night, and hear their unique voices. Some people may prefer activities in forests to those in beaches. An excellent destination for forest-based activities is *Tokoroa* in the North Island, as many people visit the mountain bike park in *Tokoroa* to enjoy off-road forest tracks.

[References]

Port of Tauranga (n.d.) Retrieved July, 2017, from
https://www.port-tauranga.co.nz/cargo-and-shipping/cruise-schedules/

Timaru District Council (n.d.) Retrieved July, 2017 from
https://www.timaru.govt.nz/community/recreation/parks-and-sports-facilities/popular-parks/caroline-bay
Hamilton & Waikato New Zealand (n.d.) Retrieved July, 2017, from
http://www.hamiltonwaikato.com/experiences/cycling/cougar-mountain-bike-park/

Neutral D: Minor Trips in New Zealand

There are many New Zealand towns that are very attractive destinations but are not well known. The North Island has *Porirua* in Wellington and *Paeroa* in Waikato. These two places have nationally famous companies. The Whittaker's chocolate factory has been in *Porirua* since 1896, and you can sample their products there. The local soft drink company L and P has been in *Paeroa* since 1904, and the town contains a big statue of the L and P bottle. The South Island also has some attractive minor destinations, such as *Rangiora* in Canterbury and *Maruia* in West Coast. There are local wineries in *Rangiora* that are becoming more popular, and winery tours are also held there. A thermal hot springs park in *Maruia* attracts many visitors, offering peace and tranquillity.

[References]

J.H. Whittakers Sons Limited (n.d.) Retrieved July, 2017, from
http://www.whittakers.co.nz/html/home/
Lemon and Paeroa (n.d.) in *Wikipedia*. Retrieved July, 2017, from
https://en.wikipedia.org/wiki/Lemon_%26_Paeroa
Rangiora (n.d.) in *Wikipedia*. Retrieved July, 2017, from
https://en.wikipedia.org/wiki/Rangiora
Maruia Hot Springs (n.d.) Retrieved July, 2017, from
http://maruiahotsprings.nz/
Geoff Collett (2013) *A Soak at Maruia* [press release]. Retrieved from
http://www.stuff.co.nz/the-press/christchurch-life/avenues/play/8958861/A-soak-at-Maruia

Māori A: Iwi in Aotearoa

Aotearoa is filled with Maori history, and the North Island has more than 50 iwi. Currently, the largest iwi is Nga Puhi, which is centred in *Whangarei* and the Bay of Islands. They have occupied the area around *Whangarei* since the early 19th Century. Te Arawa is also one of the largest iwi, and they are based in *Rotorua* and the Bay of Plenty. They originally came from the Polynesian homelands called Hawaiki to Maketu on the Bay of Plenty coast, and some of their descendants moved to the *Rotorua* area. The place name of *Taranaki* is named after the local iwi. It is not easy to determine how many iwi there are in the *Taranaki* region, because many of the descendants live outside the region. Indeed, establishing the total number of iwi in Aotearoa is not at all straightforward.

[References]

Ngāpuhi (n.d.) in *Wikipedia*. Retrieved July, 2017, from https://en.wikipedia.org/wiki/Ng%C4%81puhi

Paul Tapsell (2005) Te Arawa in *Te Ara: The Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/te-arawa

Rotorua Museum (n.d.) Retrieved July, 2017, from http://www.rotoruamuseum.co.nz/visit-us/about-te-arawa/

Taranaki Iwi: Me Tōnga Harakeke (n.d.) Retrieved July, 2017, from http://taranaki.iwi.nz/taranaki-iwi-history/

Māori B: Ngai Tahu in the South Island

Ngai Tahu is the principal Maori iwi in the South Island. Hence, the South Island is filled with the history of Ngai Tahu. For example, there were two major battles with Ngati Toa in *Kaikoura* and *Akaroa* around 1830. People from Ngati Toa attacked *Kaikoura* in 1827, and Ngai Tahu succeeded in defending their territory. A few years later, people from Ngati Toa came down to *Akaroa* to get revenge, and lots of people were killed in the war. Mt. Cook is an important place for Ngai Tahu people, and it is known as *Aoraki* to Maori. They view the summit of *Aoraki* as a sacred place, because it possesses significant tribal value as the source of the power. A part of the history of Ngai Tahu is inherited in Otago including *Moeraki* and Dunedin. The mana of Ngai Tahu has been maintained in a marae in *Moeraki* for generations.

[References]

The Whanau Show (n.d.) Ngāi Tahu. Retrieved July, 2017, from http://whanaushow.co.nz/index.php/ngai-tahu

Te Maire Tau (2005) Ngāi Tahu - Wars with Ngāti Toa in *Te Ara: The Encyclopedia of New Zealand*. Retrieved from https://www.teara.govt.nz/en/ngai-tahu/page-6

Department of Conservation: Te Papa Atawhai (n.d.) Retrieved July, 2017, from http://www.doc.govt.nz/about-us/our-partners/maori/aoraki-mount-cook/

The Armchair Mountaineer (n.d.) *Mount Cook*. Retrieved July, 2017, from http://armchairmountaineer.com/mount-cook/

Te Rūnanga O Moeraki (n.d.) Retrieved July, 2017, from http://www.moerakirunanga.co.nz/about/about.htm

Māori C: Maori Culture Experience

Many towns around Aotearoa offer a wide range of Maori cultural experiences. For example, some events to celebrate Matariki are held in *Timaru* and *Oamaru* on the Maori New Year. Kapa haka groups performed in *Timaru* on the Matariki in 2015. In addition to kapa haka, musical performances and workshops were also held in *Oamaru* this year. Another big celebratory event was held in *Tauranga* this year. 25 Matariki-themed events were held in *Tauranga* over four weeks. You can enjoy Maori culture not only in Matariki events but also in other events. For example, a cultural festival is held in *Tokoroa* every August. This event offers not only a Maori cultural experience but also other Pacific cultural experiences, and lots of people gather in *Tokoroa* every year for it.

[References]

Daniel Birchfield (2017) Matariki to be marked for first time. [press release] Retrieved from http://www.oamarumail.co.nz/community/matariki-to-be-marked-for-first-time/

Nick Truebridge (2015) Timaru Matariki celebration a 'real treat' [press release] Retrieved from https://www.stuff.co.nz/timaru-herald/news/69692513/timaru-matariki-celebration-a-real-treat

Tauranga City Council (2017) Celebrating Matariki in Tauranga moana [press release] Retrieved from http://www.sunlive.co.nz/news/152926-celebrating-matariki-tauranga-moana.html

Toi-Ohomai (n.d.) Retrieved July, 2017, from https://www.waiariki.ac.nz/employers-and-industry/sponsorship/all-sponsorships/south-waikato-cultural-festival-culturefest

Māori D: Kapa Haka Performances

Kapa haka performances are held throughout Aotearoa. Kapa haka is performed not only by Maori but also Pakeha people, and you can enjoy the performances even in small towns. There are two small towns, *Rangiora* and *Maruia*, near Christchurch. A kapa haka group performs in school assemblies and ceremonies at *Rangiora* High School, and you can also watch online videos of a kapa haka group at *Maruia* school. Kapa haka performances are also popular in *Paeroa* and *Porirua* in the North Island. There was a big kapa haka festival in *Paeroa* in 2016, and there was a secondary school kapa haka competition in *Porirua* in 2013.

[References]

Rangiora High School (n.d.) Kapa haka. Retrieved July, 2017, from http://www.rangiorahigh.school.nz/Co-Curricular/Rangiora-High-School-North-Canterbury-New-__I.1002

Maruia School (2016) Our kapa haka video. Retrieved from http://www.maruia.school.nz/2016/01/31/our-kapa-haka-video/

Waihi East School (2016) Hauraki Kapahaka Festival in Paeroa. Retrieved from http://www.waihieast.school.nz/2016/10/19/hauraki-kapahaka-festival-in-paeroa/

Eventfinda: Secondary Schools Kapa Haka Competition (2013) Retrieved from https://www.eventfinda.co.nz/2013/secondary-schools-kapa-haka-competition-whakataetae-k/porirua-mana

Filler A (neutral Filler A): Christchurch in Canterbury

Canterbury is a region of New Zealand, and it is located in the eastern part of the South Island. According to a survey in 2016, Canterbury is home to 600,100 people, and this is 13 percent of the population in New Zealand. The major city is Christchurch, and it is the third-most-populous city in New Zealand following Auckland and Wellington. Christchurch is one of the most popular tourist spots in New Zealand. Many tourists are attracted by a large park, a beautiful cathedral, and a gondola. The city centre has many fashionable shops and cafes. You can also enjoy beaches in New Brighton and Sumner.

[Reference]

John Wilson (2009) Canterbury region in *Te Ara: the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/canterbury-region

Filler B (neutral Filler B): Travels in the West Coast

The West Coast is one of the most sparsely populated areas in New Zealand. It is about 600 kilometres long and about 70 kilometres wide. It has spectacular mountains and glaciers, and they attract many tourists. There is a well-paved route beginning from Christchurch, crossing the Southern Alps, and ending with Greymouth or Hokitika. Thus, many tourists head for the West Coast. One of the most popular places is Haast. It has blue pools, and you can meet wildlife such as weka and kiwi. One of the fastest growing tourist spots is Lake Brunner, and there you can enjoy some water activities like kayaking, swimming, and boating.

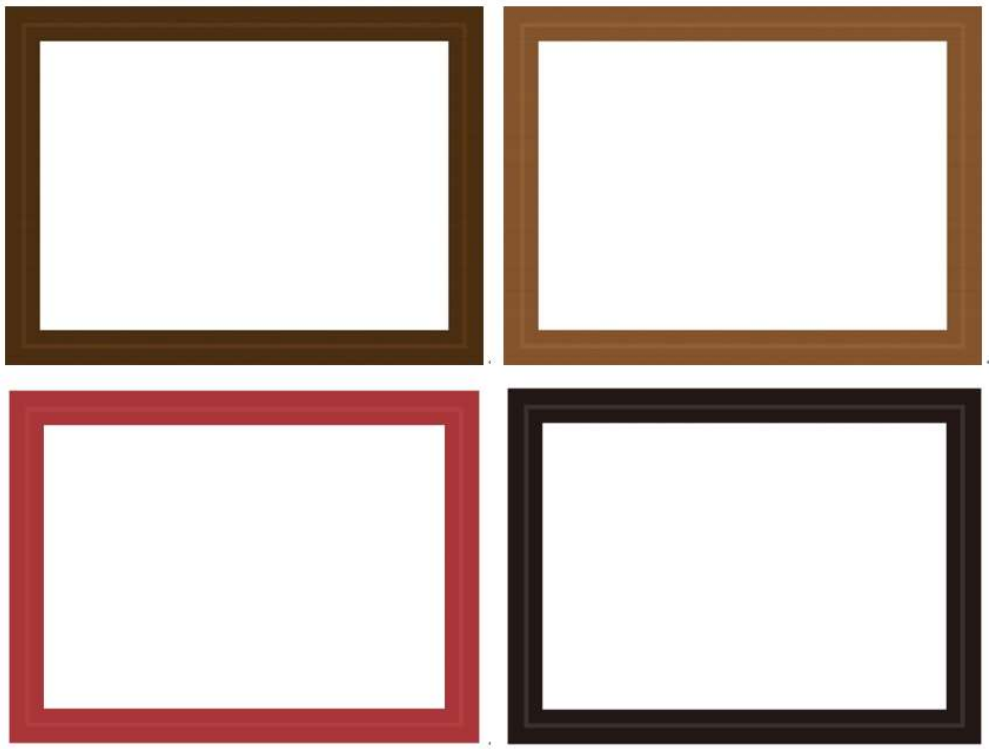
[References]

John Pascoe (1966) *The Haast is in South Westland*. Wellington: Reed.

Simon Nathan (2009) West Coast region - Tourism and outdoor recreation. n *Te Ara: the Encyclopedia of New Zealand.* Retrieved from https://teara.govt.nz/en/west-coast-region/page-12

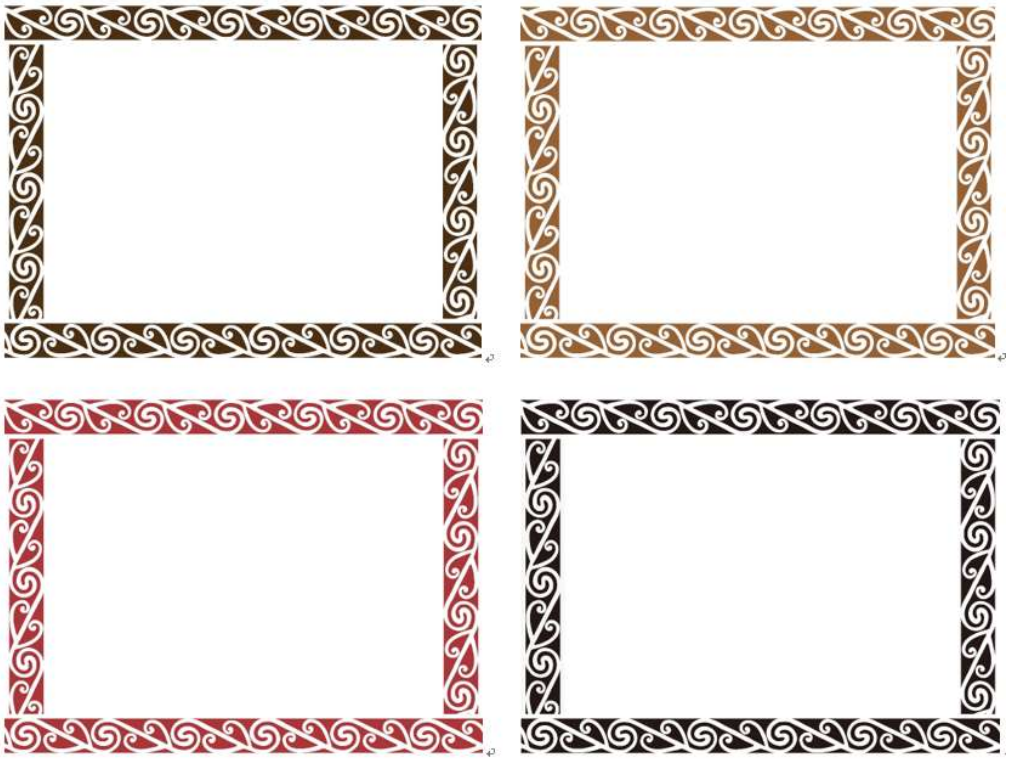
Appendix E: Cultural images (employed in Experiment 2)

Neutral frames



@Risa Kuribara 2017

Māori frames



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Appendix F: New passages (employed in Experiment 3)

Neutral A: Volcanic and geothermal activities in the North Island

The North Island has been a place where volcanic and geothermal activities have been observed for a long time. Mount *Taranaki* is one of many volcanoes within the North Island. It is believed that the volcano began erupting about 130,000 years ago, but it is now considered to be dormant. Another volcano, the *Whangarei* volcano, is located at the top of the North Island. It is believed that the first eruption was more recent than the *Taranaki* volcano, and it is still considered active. This is why the city council of *Whangarei* has a guideline on their website about what to do during an eruption. Geothermal activities are also observed in the *Rotorua* region. Because of the active geothermal vents, many tourists visit *Rotorua* to enjoy the hot water springs and see the geysers.

[References]

GNS Science Te Pū Ao (2017) Taranaki / Egmont. Retrieved from https://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/New-Zealand-Volcanoes/Taranaki-Egmont

Volcano Discovery (n.d.) Whangarei volcano. Retrieved January, 2018, from https://www.volcanodiscovery.com/whangarei.html

Whangarei District Council (n.d.) Volcanoes. Retrieved January, 2018, from http://www.wdc.govt.nz/CommunitySafetyandSupport/CivilDefence/BePrepared/Pages/Volcanoes.aspx

Neutral B: Fish culture in New Zealand

As fish and chips remain the most popular takeaway in New Zealand, fish form an important aspect of New Zealand culture. The South Island has a variety of great fishing areas. Many people go fishing on the *Moeraki* and *Kaikoura* peninsulas. You can join a day fishing tour at the *Moeraki* peninsula, and various fish charters are available at the *Kaikoura* peninsula. Fish farming is also common in the country. There are big salmon farms in the *Akaroa* and *Aoraki* areas. The salmon farm in *Akaroa* has supplied high-quality salmon to local communities for the last three decades, and the farm in the *Aoraki* region supplies a large number of alpine salmon to both New Zealand and overseas.

[References]

Moeraki Fishing Charters (n.d.) Retrieved January, 2018, from https://www.moerakifishingcharters.co.nz/pages/13-8/Day-Tours

Fish Kaikoura (n.d.) Retrieved January, 2018, from https://www.fishkaikoura.co.nz/

Akaroa Salmon (n.d.) Retrieved January, 2018, from https://akaroasalmon.co.nz/pages/why-akaroa-salmon

Mt Cook Alpine Salmon (n.d.) Retrieved January, 2018, from

http://alpinesalmon.co.nz/

Neutral C: Local economy in New Zealand

Each town in New Zealand has individual economic activities. For example, the fishing industry is active in *Timaru* and Nelson. It is known that *Timaru* has the second largest fishing port in the nation. Some places such as *Tauranga* employ exporting to boost their economy, and the Port of *Tauranga* is the largest in the nation. Many towns exploit agriculture for their livelihood. Forestry and farming make large amounts of money in the *Tokoroa* region. Forestry in *Tokoroa* is one of the largest industries in New Zealand. Some towns such as *Oamaru* depend on tourism. There are many heritage buildings in *Oamaru* town centre, which attract a lot of tourists.

[References]

Timaru (n.d.) in *Wikipedia*. Retrieved January, 2018, from
https://en.wikipedia.org/wiki/Timaru#Economy

Tauranga (n.d.) in *Wikipedia*. Retrieved January, 2018, from
https://en.wikipedia.org/wiki/Tauranga#Economy

Tokoroa (n.d.) in *Wikipedia*. Retrieved January, 2018, from
https://en.wikipedia.org/wiki/Tokoroa#Economy

Oamaru (n.d.) in *Wikipedia*. Retrieved January, 2018, from
https://en.wikipedia.org/wiki/Oamaru

Neutral D: Local events in New Zealand

Many towns in New Zealand hold various events that entertain tourists as well as residents. Music events are popular in New Zealand, and they have been held in many towns such as *Paeroa* and *Rangiora* in the past few years. A jazz event held in *Paeroa* entertained many participants with both old and modern jazz music. A music event held in *Rangiora* was a little bit unique as participants enjoyed various types of music while having a variety of food from all over the world. Sports events are also popular in New Zealand. Park jogging events are quite popular. A park running event in *Porirua* is held every Saturday morning, and many *Porirua* residents attend. Sports tournaments also entertain New Zealanders, and they are held even in small places such as the *Maruia* township. A golf tournament was held in *Maruia* this February, and it was enjoyed by both players and non-players.

Eventfinda: Paeroa Jazz Festival (2011) Retrieved from
https://www.eventfinda.co.nz/2011/aug/paeroa/paeroa-jazz-festival

Eventfinda: Rangiora Eats and Beats (2017) Retrieved from
https://www.eventfinda.co.nz/2017/eats-beats/rangiora

Eventfinda: Parkrun Porirua (2011) Retrieved from
https://www.eventfinda.co.nz/2016/parkrun-porirua/porirua-mana

Eventbrite: Reefton Golden Tee Golf Tournament (2011) Retrieved from
https://www.eventbrite.co.nz/e/reefton-golden-tee-golf-tournament-2018-tickets-

39167505062?aff=es2

Māori A: Cultural tours in North Island

Because more people belong to iwi in the North Island, many cultural tours are held there. For example, tours are held in *Whangarei* and *Rotorua* every day. If you attend a tour in the *Whangarei* district, you can learn a mihi, and how to sing a waiata. A village in *Rotorua* allows you to visit a historic site, and attend some cultural activities during the tour. In addition, you can also visit *Taranaki* to experience local iwi culture. The tour allows you to visit a meeting house, and you can also enjoy the scenery of Mount *Taranaki* nearby. Attending these tours is a nice way to learn about Maori culture.

[References]

Tu Tika Tours (n.d.) Retrieved January, 2018, from https://www.tutikatours.co.nz/

Mitai Maori Village (n.d.) Retrieved January, 2018, from http://mitai.co.nz/

New Zealand Tourism Guide (n.d.) Taranaki Maori culture. Retrieved January, 2018, from http://www.tourism.net.nz/region/taranaki/attractions-and-activities/maori-culture

Māori B: Traditional Kai

Traditional kai is a mix of hunted, gathered, and cultivated food, with fish being an important ingredient. It is known that Ngai Tahu people depended on fish caught in *Akaroa*, *Kaikoura*, and other places. It was said that in 1884 Ngai Tahu people caught 350 native mackerel in *Akaroa* in one day, and even now, there is still a large fishing community on the *Kaikoura* coast. Whales also play an important part in their food culture and whaling stations used to exist in some places such as *Moeraki* and other coastal regions. A monument was established for the whaling station in *Moeraki* in 1836. All over the country there are many places you can go to eat hangi. Iwi in the *Aoraki* region are particularly renowned for their excellent hangi, so *Aoraki* is a recommended destination for experiencing hangi.

[References]

Charles Royal, and Jenny Kaka-Scott (2013) Māori foods – kai Māori in *Te Ara: the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/maori-foods-kai-maori

W.A. Taylor (1950) Lore and history of the South Island. Retrieved from http://nzetc.victoria.ac.nz/tm/scholarly/tei-TayLore-t1-body1-d8.html

Te Korowai o Te Tai o Marokura (n.d.) Retrieved January, 2018, from http://www.teamkorowai.org.nz/about-TeamKorowai.htm

Jock Phillips (2006) Whaling: Māori and whaling in *Te Ara - the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/whaling/page-4

Malcolm McKinnon (2015) Otago region - Māori history and whaling in *Te Ara - the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/photograph/22629/moeraki-monument

Māori C: Role of art in iwi culture

Artistic expression is an important aspect of iwi culture. Two towns in the South Island, *Oamaru* and *Timaru*, play important roles in their stone art culture. Stone formed in *Oamaru* has a fine consistency, and is often used for traditional stone carving, often in the shape of a fish hook. The art centre in *Timaru* conserves ancient carvings, some of which are 500 years old. There are particularly spectacular tiki in *Tokoroa* and *Tauranga* in the North Island. Tiki are wood or stone carvings of humanoid form. Many tiki carvings were made in the *Tokoroa* town centre for the Talking Poles project, and these attract tourists as well as local people. The main street of *Tauranga* has a tiki carving, which represents the stars of Matariki and mana of the local tribes.

[References]

Simply Stone: Naturally New Zealand (n.d.) Oamaru stone carvings. Retrieved January, 2018, from http://www.simplystone.co.nz/index.php?route=product/category&path=59

Green Journeys (n.d.) Te ana Maori rock art centre. Retrieved January, 2018, from http://www.greenjourneys.co.nz/new-zealand-luxury-collection/maori-rock-art-tours.196

South Waikato District Council (n.d.) Tokoroa talking poles. Retrieved January, 2018, from http://www.southwaikato.govt.nz/our-district/arts-and-culture/talking-poles/Pages/default.aspx

Te Awanuiārangi Black (2005) Tauranga Moana - From Gate Pā to the present in *Te Ara - the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/photograph/807/carving-of-ururangi-tauranga

Māori D: Local culture in schools

These days, there are many schools offering significant cultural experiences, and providing education about iwi culture. For example, students in *Paeroa* and *Porirua* have many opportunities to attend cultural events. Students at *Paeroa* college visit a meeting house as a school trip, and those at *Porirua* college learn to give a mihi and sing waiata. Learning kapa haka is one of the most common cultural activities at school, and many students learn kapa haka even in rural places such as *Maruia* and *Rangiora* in the South Island. Students at *Maruia* School and *Rangiora* High School also have opportunities to learn te reo Maori.

[References]

Paeroa College (n.d.) Recent news. Retrieved January, 2018, from http://www.paeroacollege.school.nz/news-newsletters/recent-news

Porirua College (n.d.) Activities. Retrieved January, 2018, from

http://www.poriruacollege.school.nz/activities
Education review office: Te tari Arotake Mātauranga (2015) Maruia school. Retrieved January, 2018, from http://www.ero.govt.nz/review-reports/maruia-school-02-06-2015/
Education review office: Te tari Arotake Mātauranga (2014) Rangiora new life school. Retrieved January, 2018, from http://www.ero.govt.nz/review-reports/rangiora-new-life-school-19-12-2014/

Filler A (Māori Filler A): Variety of waka

It is believed that the first explorers to reach New Zealand travelled here using canoes. These canoes were called waka, and since then a variety of canoes have been developed for inland and coastal waterways. Small waka were used for fishing and river travel, and large ones were used for war parties. They are not used in daily life nowadays, but there are still various opportunities to learn about waka in New Zealand. Many museums conserve traditional waka, and a variety of waka are displayed. In addition, waka tours in Kaiteriteri allow you to have an authentic experience of paddling a waka.

[References]

100% Pure New Zealand (n.d.) The arrival of Māori. Retrieved July, 2017, from https://www.newzealand.com/ie/feature/early-settlement/
Hoturoa Barclay-Kerr (2006) Waka – canoes in *Te Ara: the Encyclopedia of New Zealand*. Retrieved from https://teara.govt.nz/en/waka-canoes
Waka Abel Tasman (n.d.) Retrieved July, 2017, from https://wakaabeltasman.nz/

Filler B (Māori Filler B): Story of Kupe

Polynesian people came to New Zealand more than 1000 years ago. According to oral history, the first explorer to discover the islands of New Zealand was Kupe. His journey started from his homeland Hawaiki. He and his companion, Ngahue, sailed south to see what lay beyond the horizon. His remarkable voyage was filled with lots of challenges, such as fighting a giant octopus. His arrival is of great importance, and some places around Cook Straight and Marlborough Sounds are named after his legend. The stories of Kupe and his endeavours have been passed on for generations through storytelling and song.

[References]

New Zealand Tourism Guide (n.d.) Maori stories and legend. Retrieved January, 2018, from http://www.tourism.net.nz/new-zealand/about-new-zealand/maori-stories-and-legends.html
Te Ahukaramū Charles Royal (2005) First peoples in Māori tradition – Kupe in *Te Ara - the Encyclopedia of New Zealand*. Retrieved from

https://teara.govt.nz/en/first-peoples-in-maori-tradition/page-6
https://teara.govt.nz/en/map/2390/kupes-places-around-the-marlborough-sounds

Appendix G: Code to generate Figure 7.9

```
library(ggplot2)
# Generate an exmplar space of SpeakerX, who stores a larger number of exemplars with imported structure.
Xa<-rnorm(250, mean=-50, sd=15)
Xi<-rep(0, 750)
X<-c(Xa, Xi)
# Generate an exmplar space of SpeakerY, who stores a larger number of exemplars with adapted structure.
Yi<-rep(0, 250)
Ya<-rnorm(750, mean=-50, sd=15)
Y<-c(Yi, Ya)
# Produce adapted structure by averaging phonetic values of exemplars in SpeakerX 1000 times.
# The set of 1000 produced phonetic values are called outcomeX.
outcomeX<-NULL
for (i in 1:1000){
   X<-sample(X)
   selectedX<-mean(X[1:10])
   outcomeX<-replace(outcomeX, i, selectedX)
}
# Produce adapted structure by averaging phonetic values of exemplars in SpeakerY 1000 times.
# The set of 1000 produced phonetic values are called outcomeY.
outcomeY<-NULL
for (i in 1:1000){
   Y<-sample(Y)
   selectedY<-mean(Y[1:10])
   outcomeY<-replace(outcomeY, i, selectedY)
}
# Plot the outcome formant values of Speaker X and Speaker Y together.
value<-c(outcomeY, outcomeX)
A<-rep("SpeakerY", 1000)
B<-rep("SpeakerX", 1000)
speaker<-c(A, B)
data<-data.frame(speaker, value)
ggplot(data, aes(x=value, fill=speaker))+geom_histogram(position="dodge")+xlab("outcome
    relative F3")+ylab("density")+ggtitle("Hypothetical demonstration of averaging")+
    theme(plot.title = element_text(hjust = 0.5)) + guides(fill=guide_legend (title=
    "Speaker/n(Cognitive system)"))
```

References

Adler, A. (2006). Faithfulness and perception in loanword adaptation: A case study from Hawaiian, *Lingua*, 116, 1024-1045.

Aktürk-Drake, M. (2015). *Phonological adoption through bilingual borrowing* (doctoral thesis). Stockholm University.

Aktürk-Drake, M. (2016). Language dominance as a factor in loanword phonology. *International Journal of Bilingualism*, 21, 1-16.

Albury, N. J. (2016). Defining Māori language revitalisation: A project in folk linguistics. *Journal of Sociolinguistics*, 20, 287-311.

Aylett, M., & Turk, A. (2004). The smooth signal redundancy hypothesis: A functional explanation for relationships between redundancy, prosodic prominence, and duration in spontaneous speech. *Language and Speech*, 47, 31-56.

Aylett, M., & Turk, A. (2006). Language redundancy predicts syllabic duration and the spectral characteristics of vocalic syllable nuclei. *Journal of Acoustic Society of America*, 119, 3048-3058.

Baker, R., Baese-Berk, M., Bonnasse-Gahot, L., Kim, M., van Engen, K., Bradlow, A. (2011). Word durations in nonnative English. *Journal of Phonetics*, 39, 1-17.

Baker, R., & Bradlow, A. (2009). Variability in word duration as a function of probability, speech style, and prosody. *Lang Speech*, 52, 391-413.

Bates, D., Maechler, M., Bolker, B., Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67, 1-38. arXiv: 1406.5823

Bauer, L., & Warren, P. (2008). New Zealand English: Phonology. In K. Burridge, & B. Kortmann (Eds.) *Varieties of English: The Pacific and Australia* (pp. 39-63). Berlin: Mouton de Gruyter.

Bauer, W. (1993). *Maori.* London: Routledge.

Bell, A., Brenier, J., Gregory, M., Girand, C., Jurafsky, D. (2009). Predictability effects on durations of content and function words in conversational English. *Journal of Memory and Language*, 60, 92-111.

Bell, A., Jurafsky, D., Frosler-Lussier, E., Girand, C., Gregory, M., Gildea, D. (2003). Effects of disfluencies, predictability, and utterance position on word form variation in English conversation. *Journal of Acoustical Society of America*, 113, 1001-1024.

Bell, A. (1984). Language style as audience design. *Language Society*, 13, 145-204.

Bell, A. (2001). Back in style: Reworking audience design. In P. Eckert, & J. Rickford (Eds.) *Style and sociolinguistic style* (pp. 136-169). Cambridge: Cambridge University Press.

Bell, A. (2014). *The guidebook to sociolinguistics*. New Jersey: Wiley-Blackwell.

Biggs, B. (1961). The structure of New Zealand Maaori. *Anthropological Linguistics*, 3, 1-54.

Boersma, P. (2009). Cue constraints and their interactions in phonological perception and

production. In P. Boersma, & S. Hamann (Eds.) *Phonology in perception* (pp. 55-110). Berlin: Mouton de Gruyter.

Boersma, P., & Weenink, D. (2016). Praat: Doing phonetics by computer (version 6.0.18). www.praat.org.

Bouavichith, D., & Davidson, L. (2013). Segmental and prosodic effects on intervocalic voiced stop reduction in connected speech. *Phonetica*, 70, 182-206.

Boztepe, E. (2005). Issues in code-switching: Competing theories and models. *Teachers College, Columbia University Working Papers in TESOL & Applied Linguistics*, 3.2.

Broselow, E. (2006). Loanword phonology. In K. Brown (Ed.) *Encyclopedia of language and linguistics (second edition)* (Vol. 7, pp. 286-290). Oxford: Elsevier.

Broselow, E. (2009). Stress adaptation in loanword phonology: Perception and learnability. In P. Boersma, & S. Hamann (Eds.) *Phonology in perception* (pp. 191-234). Berlin: Mouton de Gruyter.

Buizza, E., & Plug, L. (2012). Lenition, fortition and the status of plosive affrication: Spontaneous RP English /t/. *Phonology*, 29, 1-38.

Bybee, J. (2001). *Phonology and language use*. Cambridge: Cambridge University Press.

Byrd, D., & Tan, C. C. (1996). Saying consonant clusters quickly. *Journal of Phonetics*, 24, 263-282.

Calude, A. S., Miller, S., Pagal, M. (2017). Modelling loanword success – A sociolinguistic quantitative study of Māori loanwords in New Zealand English. *Corpus Linguistics and Linguistic Theory*, 1-38. doi: 10.1515/cllt-2017-0010

Campbell-Kibler, K. (2007). Accent, (ING) and the social logic of listener perceptions. *American Speech*, 82, 32-64.

Chomsky, N., & Halle, M. (1968). *Sound pattern of English*. New York: Harper & Row.

Cohen, C. (2014). Probabilistic reduction and probabilistic enhancement: contextual and paradigmatic effects on morpheme pronunciation. *Morphology*, 24, 291-323.

Cohen-Priva, U. (2012). *Sign and signal deriving linguistic generalizations from information utility* (doctoral thesis). Stanford University.

Cohen-Priva, U. (2015). Informativity affects consonant duration and deletion rates. *Laboratory Phonology*, 6, 243-278.

Cohn, A. (1993). The initial dactyl effect in Indonesian. *Linguistic Inquiry*, 24, 372-381.

Davidson, L., & Noyer, R. (1997). Loan phonology in Huave: Nativization and the ranking of faithfulness constraints. *Proceedings of the 15th West Coast Conference on Formal Linguistics*, 65-79.

Davies, C., & Maclagan, M. (2006). Māori words – Read all about it: Testing the presence of 13 Māori words in four New Zealand papers from 1997 to 2004. *Te Reo: Journal of the Linguistic Society of New Zealand*, 49, 73-99.

Davis, S., & Cho, M. (2006). Phonetics versus phonology: English word final /s/ in Korean loanword phonology. *Lingua*, 116, 1008-1023.

De Bres, J. (2010). Attitudes of non-Māori New Zealanders towards the use of Māori in New Zealand English. *New Zealand English Journal*, 24, 2-14.

Deverson, T. (1984). 'Home loans': Maori input into current New Zealand English. *English in New Zealand*, 33, 4-10.

Deverson, T. (1988). The pronunciation of Maori words in New Zealand English. *Occasional Papers in Language and Linguistics*, 1, 25-31.

Deverson, T. (1991). New Zealand English lexis: the Maori dimension. *English Today*, 26, 18-25.

Deverson, T., & Kennedy, G. (2005). *The New Zealand Oxford Dictionary*. Oxford: Oxford University Press.

Di Paolo, M., Yaeger-Dror, M., Wassink, A. B. (2011). Analysing vowels. In M. Di Paolo, & M. Yaeger-Dror (Eds.) *Sociophonetics: A student's guide* (pp. 87-106). New York: Routledge.

Docherty, G., & Foulkes, P. (2014). An evaluation of usage-based approaches to the modeling of sociophonetic variability. *Lingua*, 142, 42-56.

Dollinger, S. (2015). *The written questionnaire in social dialectology*. Amsterdam: John Benjamins.

Drager, K. (2009). *A sociophonetic ethnography of Selwyn Girl's High* (doctoral thesis). University of Canterbury.

Drager, K., Hay, J., Walker, A. (2010). Pronounced rivalries: Attitudes and speech production. *Te Reo: Journal of the Linguistic Society of New Zealand*, 53, 27-53.

Eckert, P. (2000). *Linguistic variation as social practice: The linguistic construction of identity in Belten High*. Malden: Blackwell Publishers.

Eckert, P. (2005). Variation, convention, and social meaning. Paper presented at the annual meeting of the Linguistic Society of America.

Eckert, P. (2008). Variation and the indexical field. *Journal of Sociolinguistics*, 12, 453-476.

Eckert, P. (2016). Variation, meaning and social change. In N. Coupland (Ed.) *Sociolinguistics: Theoretical debates* (pp. 68-85). Cambridge: Cambridge University Press.

Ernestus, M., & Baayen, M. H. (2011). Corpora and exemplars in phonology. In J. Goldsmith, J. Riggle, A. Yu (Eds.) *The handbook of phonological theory (Second Edition)* (pp. 374-400). Malden & Oxford: Blackwell Publishers.

Fiasson, R. (2015). *Allophonic imitation within and across word positions* (doctoral thesis). University of Canterbury & Université dAix-Marseille.

Field, A., Miles, J., & Field, Z. (2012). *Discovering statistics using R*. London: Sage publications.

Foulkes, P., & Docherty, G. (2006). The social life of phonetics and phonology. *Journal of Phonetics*, 34, 409-438.

Foulkes, P., Docherty, G., Hufnagel, S. S., Hughes, V. (2018). Three steps forward for predictability. Consideration of methodological robustness, indexical and prosodic factors,

and replication in the laboratory. *Linguistic Vanguard* 4. 2017-0032.

Foulkes, P., Docherty, G., Jones, M. (2010). Analysing stops. In M. Di Paolo, & M. Yaeger-Dror (Eds.) *Sociophonetics: A student's guide* (pp. 58-71). New York: Routledge.

Fowler, C.A., & Housum, J. (1987). Talkers' signaling of "new" and "old" words in speech and listeners' perception and use of the distinction. *Journal of memory and language*, 26, 489-504.

Friesner, M. (2009). *The social and linguistic predictors of the outcomes of borrowing in the speech community of Montréal* (doctoral thesis). University of Pennsylvania.

Friesner, M. (2010). Loanword adaptation in the French of Spanish-speaking immigrants in Montréal. In K. Arregi, Z. Fagyal, S. Montrul., A. Tremblay (Eds.) *Romance linguistics 2008* (pp. 39-56). Amsterdam: John Benjamins.

Gahl, S. (2008). Time and thyme are not homophones: The effects of lemma frequency on word durations in spontaneous speech. *Language*, 84, 272-296.

German, J. S., Carlston, K., Pierrehumbert, J. B. (2013). Reassignment of consonant allophones in rapid dialect acquisition. *Journal of Phonetics*, 41, 228-248.

Giles, H., Coupland, N., Coupland, J. (1991). Accommodation theory: communication, context, and consequence. In H. Giles, J. Coupland, N. Coupland (Eds.) *Contexts of accommodation developments in applied sociolinguistics* (pp. 1-68). Cambridge: Cambridge University Press.

Gimson, A. C. (1970). *An introduction to the pronunciation of English (Second Edition).* London: Edward Arnold.

Goldinger, S. D. (1997). Word and voices: Perception and production in an episodic lexicon. In K. Johnson, & J. W. Mullenix (Eds.) *Talker variability in speech processing* (pp. 33-66). San Diego: Academic Press.

Goldsmith, J. (2002). Probabilistic models of grammar: Phonology as information minimization. *On-in Kenkyū* [Phonological Studies], 5, 21-46.

Gordon, E., & Deverson, T. (1998). *New Zealand English and English in New Zealand*. Auckland: New House.

Hall, K., Hume, E., Jaeger, T. F., Wedel, A. (2016). The message shapes phonology. Unpublished manuscripts. https://www.researchgate.net/publication/309033386_The_Message_Shapes_Phonology/download

Hall, K., Hume, E., Jaeger, T. F., Wedel, A. (2018). The role of predictability in shaping phonological patterns. *Linguistic Vanguard*, 4, 2017-0027.

Hall-Lew, L., Starr, R., Coppock, E. (2012). Style-shifting in the US congress: The vowels of 'Iraq(i)'. In: J. M. H. Campoy & J. A. C. Espinosa (Eds.) *Style-shifting in Public: New perspectives on stylistic variation* (pp.45-63). Amsterdam: John Benjamins.

Hammond, M. (1999). *The phonology of English*. Oxford: Oxford University Press.

Harlow, R. (2007). *Māori: A Linguistic Introduction*. Cambridge: Cambridge University Press.

Hashimoto, D., & Hume, B. (2018). Effect of stress on the realization of plosives in New

Zealand English. *Te Reo: Journal of the Linguistic Society of New Zealand*, 61, 1-19.
Haugen, E. (1950). The analysis of linguistic borrowing. *Language*, 26, 210-231.
Hay, J., & Drager, K. (2010). Stuffed toys and speech perception. *Linguistics*, 48, 865-892.
Hay, J., & Foulkes P. (2016). The evolution of medial /t/ over real and remembered time. *Language*, 92, 298-330.
Hay, J., & Maclagan, M. (2012). /r/ sandhi in early 20th century New Zealand English. *Linguistics*, 50, 745-763.
Hay, J., Maclagan, M., Gordon, E. (2012). *New Zealand English*. Edinburg: Edinburg University Press.
Hay, J., Nolan A., Drager, K. (2006). From fush to feesh: Exemplar priming in speech perception. *The Linguistic Review*, 23, 351-379.
Herd, J. (2005). Loanword adaptation and the evolution of similarity. *Toronto Working Papers*, 24, 65-116.
Hillenbrand, J., Getty, L., Clark, M., Wheeler, K. (2009). Acoustic characteristics of American English vowels. *Journal of Acoustical Society of America*, 97, 3099-3111.
Hohepa, P. (1967). *A profile generative grammar of Maori*. Indiana: Waverly Press.
Holden, K. (1976). Assimilation rates of borrowings and phonological productivity. *Language*, 52, 131-147.
Holmes, J. (2008). *An introduction to sociolinguistics (Third Edition)*. London: Pearson Longman.
Honeybone, P. (2012). Lenition in English. In T. Nevalainen, & E. C. Traugott (Eds.) *Oxford handbook of the history English* (pp. 773-787). Oxford: Oxford University Press.
Hsu, B., & Jesney, K. (2016). Loanword adaptation in Québec French. *Proceedings of the 34th Meeting of the West Coast Conference on Formal Linguistics*. 249-258.
Hume, E. (2016). Phonological markedness and its relation to the uncertainty of words. *On-in Kenkyū* [Phonological Studies], 19, 107-116.
Hume, E., & Mailhot, F. (2013). The role of entropy and surprisal in phonologization and language change. In E. Hume, & K. Johnson (Eds.) *Origins of sound patterns: Approaches to phonologization* (pp. 29-50). Oxford: Oxford University Press.
Itō, J., & Mester, A. (1999). The structure of the phonological lexicon. In N. Tsujimura (Ed.) *The handbook of Japanese linguistics* (pp. 62-100). Malden & Oxford: Blackwell Publishers.
Itō, J., & Mester, A. (2001). Covert generalizations in Optimality Theory: The role of stratal faithfulness constraints. In The Phonology-Morphology Circle of Korea (Ed.) *Proceedings of the 2001 international conference on phonology and morphology*, 3-33.
Jaeger, T. F., & Buz, E. (2017). Signal reduction and linguistic encoding. In E. M. Fernández, & H. S. Cairns (Eds.) *The handbook of psycholinguistics* (pp. 38-81). New Jersey: Wiley-Blackwell.
Johnson, K. (1997). Speech perception without speaker normalization: an exemplar model. In

K. Johnson, & J. Mullenix (Eds.) *Talker variability in speech processing* (pp. 145-166). New York: Academic Press.

Johnson, K. (2011). *Acoustic and auditory phonetics*. New Jersey: Wiley-Blackwell.

Jones, M. J., & McDougall, K. (2009). The acoustic character of fricated /t/ in Australian English: A comparison with /s/ and /ʃ/. *Journal of the International Phonetic Association*, 39, 265-289.

Jurafsky, D., Bell, A., Gregory, M., Raymond, W. (2001). Probabilistic relations between words: Evidence from reduction in lexical production. In J. Bybee, & P. Hopper (Eds.) *Frequency and the emergence of linguistic structure* (pp. 229-254). Amsterdam: Benjamin.

Kager, R. (1997). *Optimality Theory*. Cambridge: Cambridge University Press.

Kaneko, E., & Iverson, G. K. (2009). Phonetic and other factors in Japanese on-line adaptation of English final consonants. In S. Inagaki, & M. Hirakawa (Eds.) *Studies in language sciences 8* (pp. 179-185).

Kang, Y. (2011). Loanword Phonology. In M. Oostendorp, C. Ewen, E. Hume, K. Rice (Eds.) *The Blackwell companion to phonology 5* (pp. 2258-2282). Malden & Oxford: Blackwell Publishers.

Kenstowicz, M. (2003). The role of perception in loanword phonology. *Studies in African Linguistics*, 32, 95-112.

Kenstowicz, M. (2007). Salience and similarity in loanword adaptation: A case study from Fijian. *Language Sciences*, 29, 316-340.

Kenstowicz, M., & Suchato, A. (2006). Issues in loanword adaptation: A case study from Thai. *Lingua*, 116, 921-949.

King, J. (1993). Maori English: a phonological study. *New Zealand English Newsletter*, 7, 33-47.

Kuznetsova, A., Brockhoff, P. B., Christensen, R. H. B. (2016). lmerTest: Tests in linear mixed effects models. R package version 2.0-32. https://CRAN.R-project.org/package=lmerTest

Labov, W. (1963). The social motivation of a sound change. *Word*, 19, 273-309.

Labov, W. (1972). *Sociolinguistic patterns*. Philadelphia: University of Pennsylvania Press.

LaCharité, D., & Pradis, C. (2005). Category preservation and proximity versus phonetic approximation in loanword adaptation. *Linguistic Inquiry*, 36, 223-258.

Ladefoged, P. (2006). *A Course in Phonetics (Fifth Edition)*. Boston: Thomson Higher Education.

Lavoie, L. (2001). *Consonant strength: Phonological patterns and phonetic manifestation*. New York: Routledge.

Lawson, E., Stuart-Smith, J., Scobbie, J. M., Yaeger-Dror, M., Maclagan, M. (2011). Analyzing Liquids. In M. Di Paolo, & M. Yaeger-Dror (Eds.) *Sociophonetics: A student's guide* (pp. 73-86). New York: Routledge.

Le Page, R. B., & Tabouret-Keller, A. (1985). *Acts of identity: Creole-based approaches to language and ethnicity*. Amsterdam: John Banjamins.

Lev-Ari, S., & Peperkamp, S. (2014). An experimental study of the role of social factors in language change: The case of loanword adaptations. *Laboratory Phonology*, 5, 379-401.

Lev-Ari, S., Giacomo, M. S., Peperkamp, S. (2014). The effect of domain prestige and interlocutors' bilingualism on loanword adaptations. *Journal of Sociolinguistics*, 18, 658-684.

Levy, R., & Jaeger, T. F. (2007). Speakers optimize information density through syntactic reduction. *Advances in Neural Information Processing Systems*, 19, 849-856.

Lindau, M. (1985). The story of /r/. In Fromkin, V.A. (Ed.) *Phonetic linguistics* (pp. 157-168). Orlando: Academic Press.

Lindblom, B. (1968). Temporal organisation of syllable production. *Speech transmission laboratory, Quarterly progress and status report*, 1-5.

Llamas, C., & Watt, D. (2014). Scottish, English, British?: Innovations in attitude measurement. *Language and Linguistics Compass*, 8, 610-617.

Loakes, D., & McDougall, K. (2010). Individual variation in the frication of voiceless plosives in Australian English: A study of twins speech. *Australian Journal of Linguistics*, 30, 155-181.

Logie, R., Aberdeen, S., Baddeley, A. (1986). Cognitive processes in counting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13, 310-326.

Love, J., & Walker, A. (2013). Football versus football: Effect of topic on /r/ realization in American and English sports fans. *Language and Speech*, 56, 443-460.

Macalister, J. (2004). A Survey of Maori Word Knowledge. *English in Aotearoa*, 52, 69-73.

Macalister, J. (2005). *Dictionary of Maori words in New Zealand English*. Oxford: Oxford University Press.

Macalister, J. (2006a). The Maori presence in the New Zealand lexicon, 1850-2000: Evidence from a corpus-based study. *English World-Wide*, 27, 1-24.

Macalister, J. (2006b). Of weka and waiata: Familiarity with borrowings from Te Reo Maori. *Te Reo: Journal of the Linguistic Society of New Zealand*, 49, 101-124.

Macalister, J. (2007). Revisiting weka and waiata: Familiarity with Maori words among older speakers of New Zealand English. *New Zealand English Journal*, 21, 34-43.

MacFarlane, A. W., & Stuart-Smith, J. (2012). 'One of them sounds sort of Glasgow Uni-ish.' Social judgements and fine phonetic variation in Glasgow. *Lingua*, 122, 764-778.

Maclagan, M., & King, J. (2005). A note on the realization of /r/ in the word Māori. *New Zealand English Journal*, 18, 35-39.

Matthews R. J. H. (1984). Maori Influence on New Zealand English. *World Language English*, 3, 156-159.

McCarthy, J. (2002). *A thematic guide to Optimality Theory*. Cambridge: Cambridge University Press.

McCarthy, J. (2008). *Doing Optimality Theory*. Oxford, Blackwell.

McEntegart, D., & Le Page, R. B. (1982). Appraisal of the statistical techniques Used in the

sociolinguistic survey of multilingual communities. In S. Romaine (Ed.) *Sociolinguistic variation in speech communities* (pp. 105-124). London: Edward Arnold.

Mendoza-Denton, N. (1999). Sociolinguistics and linguistic anthropology of US Latinos. *Annual Review of Anthropology*, 28, 375-395.

Mendoza-Denton, N., Hay, J., Jannedy, S. (2003). Probabilistic sociolinguistics: Beyond variable rules. In R. Bob, J. Hay, S. Jannedy (Eds.) *Probabilistic linguistics* (pp. 99-138). Cambridge: MIT Press.

Munson, B. (2007). Lexical access, lexical representation, and vowel production. *Laboratory Phonology*, 6, 201-228.

Myers-Scotton, C. (1992). Comparing codeswitching and borrowing. *Journal of Multilingual and Multicultural Development*, 13, 19-39.

Myers-Scotton, C. (2002). *Contact linguistics: Bilingual encounters and grammatical outcomes*. Oxford: Oxford University Press.

Nielsen, K. (2011). Specificity and abstractness of VOT imitation. *Journal of Phonetics*, 39, 132-142.

Oh, Y. M., Backner, C., Hay, J., King, J. (2018). Non-Māori-speaking New Zealanders' native-like phonotactic knowledge of Māori. Paper presented at Language and Society Conference 2018.

Olive, J., Greenwood, A., Colemen, J. (1993). *Acoustics of American English speech*. New York: Springer.

Paradis, C. (1996). The inadequacy of filters and faithfulness in loanword adaptation. In J. Durand, & B. Laks (Eds.) *Current trends in phonology: Models and methods*. (pp. 509-534). Salford: University of Salford Publication.

Paradis, C., & LaCharité, D. (1997). Preservation and minimality in loanword adaptation. *Journal of Linguistics*, 33, 379-430.

Paradis, C., & LaCharité, D. (2011). Loanword adaptation: From lessons learned to findings. In J. Goldsmith, J. Riggle, A. Yu (Eds.) *The handbook of phonological theory (Second Edition)* (pp. 751-778). Malden & Oxford: Blackwell Publishers.

Paradis, C., & Prunet, J. F. (2000). Nasal Vowels as Two Segments: Evidence from Borrowings. *Language*, 76, 324-357.

Pate, J. K., & Goldwater, S. (2015). Talkers account for listener and channel characteristics to communicate efficiently. *Journal of Memory and Language*, 78, 1-17

Peperkamp, S., & Dupoux, E. (2002). Loanword adaptations: Three problems for phonology. Paper presented at the North American Phonology Conference.

Pierce, J. (1980) *An introduction to Information Theory (Second Edition)*. New York: Dover.

Pierrehumbert, J. B. (2001). Exemplar dynamics, word frequency, lenition, and contrast, In J. Bybee, & P. Hopper (Eds) *Frequency effects and the emergence of linguistic structure* (pp. 135-157). Amsterdam: John Benjamins.

Pierrehumbert, J. B. (2002). Word-specific phonetics. *Laboratory Phonology*, VI, 101-139.

Poplack, S., & Dion, N. (2012). Myths and facts about loanword development. *Language Variation and Change*, 24, 279-315.

Poplack, S., & Sankoff, D. (1984). Borrowing: the Synchrony of Integration. *Linguistics*, 22, 99-135.

Poplack, S., Sankoff, D., Miller, C. (1988). The social correlates and linguistic processes of lexical borrowing and assimilation. *Linguistics*, 26, 47-104.

Prince, A., & Smolensky, P. (1993/2004). *Optimality Theory: Constraint interaction in Generative Grammar*. Malden & Oxford: Blackwell. [Revision of 1993 technical report, Rutgers University Center for Cognitive Science. Available on Rutgers Optimality Archive, ROA-537.]

R Core Team. (2016). R: A language and environment for statistical computing (version 3.2.4). R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Redinger, D. (2010). *Language attitudes and code-switching behaviour in a multilingual educational context: The case of Luxembourg* (doctoral thesis). University of York.

Revelle, W. (2017). Psych: Procedures for personality and psychological research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych

Rickford, J., & McNair-Knox, F. (1994). Addressee- and topic- influenced style shift: A quantitative sociolinguistic study. In D. Biber, & E. Finegan (Eds.) *Sociolinguistic perspectives on register* (pp. 235-276). Oxford: Oxford University Press.

Rose, D. (2017). *Predicting plurality: An examination of the effects of morphological predictability on the learning and realization of bound morphemes* (doctoral thesis). University of Canterbury.

Seyfarth, S. (2014). Word informativity influences acoustic duration: Effects of contextual predictability on lexical representation. *Cognition*, 133, 140-155.

Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, 27, 329-423.

Shaw, J., & Kawahara, S. (2017). Effects of surprisal and entropy on vowel duration in Japanese. *Language and Speech*, 1-35. doi: 10.1177/0023830917737331

Shaw, J., & Kawahara, S. (2018). Predictability and phonology: Past, present and future. *Linguistic Vanguard*, 4, 2018-0042.

Sigley, R. (2018). Variable use of diacritics to mark loanwords in New Zealand English. Paper presented at Language and Society Conference 2018.

Silverman, D. (1992). Multiple scansions in loanword phonology: Evidence from Cantonese. *Phonology*, 9, 289-328.

Sóskuthy, M., & Hay, J. (2017). Changing word usage predicts changing word durations in New Zealand English. *Cognition*, 166, 298-313.

Szakay, A. (2007). *Identifying Māori English and Pākehā English from suprasegmental cues: A study based on speech resynthesis* (master thesis). University of Canterbury.

Tajfel, H. (1978). *Differentiation between social groups*. London: Academic Press.

Taylor, B. (1996). Gay men, femininity, and /t/ in New Zealand English. *Wellington Working Papers in Linguistics*, 8, 70-92.

Te Kupenga. (2013). *Statistics New Zealand's first survey on Māori well-being*. http://archive.stats.govt.nz/~/media/Statistics/Browse%20for%20stats/TeKupenga/HOTP13/TeKupenga13HOTP.pdf

Te Manatū Taonga. (2009). *How important is culture? New Zealand's views in 2008 — An overview*. http://www.mch.govt.nz/files/HowImportantIsCulture.pdf

Te Puni Kōkiri. (2006). *Te Oranga o te Reo Māori (The health of the Māori language in 2006)*. https://www.tpk.govt.nz/documents/.../67/tpk-2008-health-maori-language-2006.pdf

Te Puni Kōkiri. (2009). *2009 rangahau i ngā waiaro, ngā uara me ngā whakapono mō te reo Māori (2009 survey of attitudes, values and beliefs towards the Māori language)*. http://www.tpk.govt.nz/documents/download/264/2010%2009%2001%20RP%202009%20Survey%20of%20Attitudes,%20Values%20and%20Beliefs%20Towards%20the%20Maori%20Language.pdf

Todd, S., Pierrehumbert, J. B., Hay, J. (2019). Word frequency effects in sound change as a consequence of perceptual asymmetries: An exemplar-based model. *Cognition*, 185, 1-25.

Turk, A. (2012). The temporal implementation of prosodic structure. In A. Cohn, C. Fougeron, M. Huffman (Eds.) *Oxford handbook of laboratory phonology* (pp. 242-253). Oxford: Oxford University Press.

Uffman, C. (2006). Epenthetic vowel quality in loanwords: Empirical and formal issues. *Lingua*, 116, 1079-1111.

Umeda, N. (1977). Consonant duration in American English. *Journal of Acoustical Society of America*, 61, 846-858.

Walker, A. (2014). *Crossing oceans with voices and ears: Second dialect acquisition and topic-based shifting in production and perception* (doctoral thesis). University of Ohio.

Walker A., & Hay J. (2011). Congruence between 'word age' and 'voice age' facilitates lexical access. *Laboratory Phonology*, 2, 219-237.

Wang, X. (2017). *Exploring the role of attitudes in new dialect formation in Hohhot, China* (doctoral thesis). University of Canterbury.

Warner, N., & Tucker, B. (2010). "Ok, whatever!": Phonetic variability of stops and flaps in spontaneous and careful speech. *Phonology*, 27, 289-324.

Watt, D., Fabricius, A., Kendall, T. (2011). More on vowels: Plotting and normalization. In M. Di Paolo, & M. Yaeger-Dror (Eds.) *Sociophonetics: A student's guide* (pp. 107-118). New York: Routledge.

Wedel, A. (2006). Exemplar models, evolution and language change. *The Linguistic Review*, 23, 247-274.

Wells, J. (1982). *Accents of English 1: An introduction*. Cambridge: Cambridge University Press.

Winter, B. (2013). Linear models and linear mixed effects models in R with linguistic applications. arXiv:1308.5499. http://arxiv.org/pdf/1308.5499.pdf

Wolfram, W., & Schilling, N. (2016). *American English: Dialects and variation*. Malden & Oxford: Blackwell Publishers.

Wright, C. E. (1979). Duration differences between rare and common words and their implications for the interpretation of word frequency effects. *Memory and Cognition*, 7, 411-419.